REPORT

OF

TOPOGRAPHIC AND GEOLOGIC SURVEY COMMISSION

OF

PENNSYLVANIA

1910-1912

COMPLIMENTS OF
Richard R. Rice

TOPOGRAPHIC

AND

GEOLOGICAL SURVEY

OF

PENNSYLVANIA

1910-1912

HARRISBURG:
C. E. AUGHINBAUGH, PRINTER TO THE STATE OF PENNSYLVANIA
1912


VIRTUE
LIBERTY AND
INDEPENDENCE

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LETTER OF TRANSMITTAL

To His Excellency, John K. Tener, Governor, and the Legislature of Pennsylvania:

Sirs: The undersigned, Commissioners of the Topographic and Geologic Survey of Pennsylvania, have the honor to submit the following report of the work accomplished during the fiscal years ending June 30, 1911 and June 30, 1912.

Very respectfully,

GEORGE W. McNEES,
ANDREW S. McCREATH,
EDWARD V. D'INVILLIERS,

Harrisburg, Pennsylvania, August 3, 1912.

TOPOGRAPHIC AND GEOLOGIC SURVEY OF PENNSYLVANIA

Historical. The work done under the direction of this Commission was originally started under an Act of Assembly approved April 28, 1899. Under the provisions of that Act, the Commission then appointed entered into a contract with the United States Geological Survey for the preparation of a Topographic Map of Pennsylvania on a scale of 1 to 62,500, with contours for each 20 feet of elevation. Included in this contract were provisions for geological work on a co-operative basis, (see Appendix A).

The results of the work under the above mentioned agreement, and supplements thereto continuing the same in force will be found in four reports. The first covered the work accomplished for the period ending June 30th, 1901; the second included the work to June 1st, 1906; the third recorded results to the close of the year June 1st, 1908; and the fourth treated of the work of the years 1908-1909 and 1909-1910.

In addition to the reports published by the State the results of the co-operative geologic work done under this contract have appeared in the publications of the United States Geological Survey and all completed maps have been issued by that organization. The results of the Topographic work are graphically shown on the Index Maps included in this report.

During the period covered by this report Topographic work has been continued in the State under the provision of the contract above referred to, but during the last two years there has not been any new co-operative geological work undertaken, though the unfinished work previously arranged for has been pushed toward completion and there now remains for publication by the Federal Survey the results of the work on but five quadrangles. The arrangements of the United States Geological Survey, which has entire charge of the co-operative work, are such that we expect a prompt completion of the reports on these remaining quadrangles.

Geologic work has been carried on by the State independently during the last two years in accordance with the Act of Assembly authorizing the some, (see Appendix A), as will be described later in this report, but the appropriations available have been too meagre to accomplish what is urgently demanded.

Topographic Work. There have been no changes made in the methods adopted for topographic maping which were briefly described in former reports.

Pennsylvania has an estimated area of 45,126 square miles and for the Topographic mapping of this area it is divided into quadrangles of 15 minutes on each side. The State lines do not coincide with the lines of these quadrangles and, therefore, there will be a number of quadrangles in the completed map which will necessarily embrace portions of adjoining States.

The total number of quadrangles lying wholly or partly within the State will be about 240 and the complete map of the State will be composed of that number of sheets.

During the past two years there has been relatively little control work done in the State owing to the small amount of funds available. In the Eastern portion of the State primary horizontal control has been extended over the Wind Gap and Mauch Chunk quadrangles by the extension of the triangulation net over this area, and the location of the necessary points to properly control the same. The area embraced in these quadrangles is one of very considerable economic importance and it is proposed to complete the mapping of this region as early as possible.

In the northwestern portion of the State control has been extended by primary traverse over the Northeast quadrangle, the primary traverse lines being tied to the stations of the Lake Survey and the boundary monuments of the New York and Pennsylvania State Line. This is the only area remaining unmapped along the southern shores of the Great Lakes and its mapping will close the gap in that region and enable the completion of the studies of the old abandoned Lake beaches of the Erie basin, and the determination of the changes in level which have taken place since these old strand lines were formed by the waters of the receding glacial lakes.

In the southern portion of the State a number of quadrangles in the Somerset region have remained unmapped and uncontrolled. It was attempted several years since to control this area but the weather conditions during the field season were such as to prevent satisfactory results. During the time covered by this report the primary control by triangulation has been extended so to cover the Wilpen, Stahlstown, Somerset, Windber, Confluence, Myersdale, Hyndman, Berlin and Clearville quadrangles. Some work has also been done in the past in the way of horizontal control by the extension of level lines across this area. Probably in no portion of the State, of an equal area, is there more industrial development in progress than in this Somerset region. The opening of coal mines is taking place rapidly and geological work in the area is urgently needed at the present time.

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With this in view work on the detail mapping of two of these quadrangles will be undertaken during the coming field season.

The details of this new control work will be found in report Number 7 of this Survey which contains the information of an engineering nature connected with the horizontal and vertical control and topographic work in the State.

It has been thought desirable that names be assigned to all the quadrangles in the State, whether the same have been mapped or not, and names have been given to all unmapped quadrangles during the last two years. These are shown on the Index Map, plate I, and will permit of future reference to any particular area with much greater ease then heretofore. This Index Map will also show the quadrangles within which mapping has been completed and for which maps can be had from the United State Geological Survey. Of the total number of sheets 137 have been issued, covering a total area of 23,322.19 square miles or 51.7 per cent. of the total area of the State.

It has been impossible with the funds available to extend the primary control either horizontal or vertical to the limits desired nor has it been possible to complete the detail mapping of but a small portion of the area where it is needed. To economically do Topographic mapping it is necessary that the control, both horizontal and vertical, be carried ahead of the detail work. This was done in the early years of the present Survey when the work of the Coast and Lake Surveys could be utilized and a considerable amount of new work was done by the present organization. But with the diminished funds available this control work had to be curtailed and if the Topographic mapping of the State is to be continued it is most desirable, and indeed necessary, that there be sufficient funds provided to admit of an allotment of $5,000 for each of the next two years by this Survey to carry forward this very essential work.

The Topographic relief of much of the State is such that to do primary control work in an economical manner it should embrace a large area and be done sufficiently far in advance of the final mapping to permit of the necessary office work and plotting of the data before the detailed field work is attempted.

The demand for topographic results is not confined to any special portion of the State; nor is it confined to those portions where the greatest industrial developments are in progress. If a larger amount of topographic work is to be done, commensurate with the area of the State remaining unmapped and the important and growing demand for the work, it is desirable that such appropriations should be provided as will admit the allotment of the greatest possible amount of money for this purpose which the Federal Survey will supplement by an equivalent allotment. In some of our adjoining States the importance of the topographic maps is so fully realized that not only

is the State allotment of funds made the greatest that will be met by the United States Survey, but additional work is being done over and above that done co-operatively and paid for by the State alone, the work being done by the United States Survey, and the results being used by that organization as well as the State.

With but half the area of Pennsylvania so mapped to date, and the efficiency of the Survey impaired for the lack of proper base upon which to corectly represent the geologic structure and economic resources, it is a matter of prime importance to the Commonwealth to recognize the deficiency and provide for a more consistant and rapid completion of the work.

Geologic Work. Under the co-operative arrangement with the Federal Survey thirty-one quadrangles have been studied, on most of which reports have been published. During the last two years the Warren folio, the Sewickley folio, the Foxburg-Clarion (a double folio), the Burgettstown-Carnegie, (a double folio), the Claysville folio and Johnstown folio have been issued. The geological work on the New Castle, Punxsutawney, Barnesboro, Patton and Houtzdale quadrangles has been completed and the manuscripts are in a more less advanced state. It is expected that all of these will be submitted for publication by the United States Geological Survey during the next year.

A full list of the folios covering the various quadrangles surveyed in co-operation, and by the United States Geological Survey alone, and of the Bulletins treating of the economical features of the same areas will be found in Appendix B, as also the references to a number of papers scattered through the publication of the United States Survey, relating to various phases of Pennsylvania geology.

During the time covered by this report geological work has been carried along by the State Survey in several portions of the State so far as the funds available would permit; but it is pertinent to remark that even the little accomplished was only made possible by the co-operation of those gentlemen who devoted much time and their private information to this work, without consideration of the wholly inadequate compensation made to them.

Two oil reports, one covering the Oil and Gas resources of the Sewickley quadrangle, and the other the Oil and Gas Resources of the Clarion quadrangle have been issued as reports of this Survey. These are the results of work done in co-operation with the United States Geological Survey.

During the pas year Report No. 4, of this Survey, on the Mineral Pigments of Pennsylvania, by Dr. B. L. Miller, has been issued. This covers in detail the mineral paints and pigments of the State, treating of the same from a strictly economical standpoint

The report of Dr. F. B. Peck on the Talc and Serpentine of the State, and a preliminary report by the same author on the Cement

Materials and the Cement Industry of the Lehigh Region has been issued as Report No. 5. While this purports to be but a preliminary report it is far more, treating of these industries quite fully and discussing the materials, their mode of occurrence and geologic age, the development and growth of the Portland Cement Industry of the Lehigh District, and of the United States, the several mills and kilns which have been used during the various stages of development and the possibilities of future growth of the industry.

The biennial report, covering the work of the two years 1908-1910, was issued and in addition to the ordinary statement of work done the report contained a short discussion of the relative position and rank of Pennsylvania as a mineral producer as compared with the United States and other states, together with the results of primary traverse and leveling during the years covered by the report.

There was also included a timely paper by Frederick G. Clapp on the "Present Status of the Natural Gas Development of Pennsylvania Fields," and also a "Preliminary List of the Fossils of the Allegheny and Conemaugh Series in Western Pennsylvania," by Dr. Percy E. Raymond, accompanied by four plates of typical fossils. A valuable contribution to the literature treating of these measures

A report on the Graphite Deposits of Pennsylvania by Dr. B. L. Miller has been prepared and the manuscript placed in the hands of the State Printer. While graphite is one of the minerals of lesser importance in Pennsylvania it is but one of a number of such minerals, which in the aggregate form a large part of the mineral wealth of the State, and all of which are deserving of study. This report should be ready for distribution during the summer of 1912.

The slate deposits of Lehigh and Northampton counties have been studied by A. P. Berlin, particularly in connection with their economic resources. The work thus far has been confined to the western portion of the area, and is rapidly approaching completion. The manuscript for a report on this portion of the slate area will be ready for submission during the summer of 1912.

A report on the minerals of Pennsylvania by Dr. Amos P. Brown has been in active preparation. This is not intended to include the minerals of rare occurrence in the State, but will be a short account of the deposits of economic importance, or which may become of value. There has been quite a demand for such a report, and it is expected this will be ready for distribution during the coming winter.

The Broad Top coal field of Huntingdon and Bedford counties has also received some preliminary consideration as it was thought timely to give attention to this field, almost neglected in the work of the Second Geological Survey through failure of success in legislation to provide the means to properly map and study this unique field of plicated coal.

Even now the difficulty of delineating the detailed geology and structure of this area is fully realized in the absence of a good topographic base upon which to orient the data available through the assured co-operation of the several corporations and individuals engaged in mining there.

But during the past winter a general map of the field has been compiled, incorporating data available from various mine maps, and brought to a common scale and the field work can now be arranged for. The more this field is investigated the more certain it appears that the peculiar problems found there are deserving of study. There is a large amount of coal still available and while upwards of thirty million tons have been produced in the limited area occupied by a remnant of the original coal deposit, it is expected to furnish several times that amount in the future of a coal adapted for special markets.

Considerable work has been done in the collection of information relative to the Clay Working Industry of the western part of the State, which may be called the Fire Brick portion of the State. This work will be continued and a report issued on the same. Pennsylvania is the greatest brick and tile producing State in the country, a large portion of the industry being fire brick and this first report on the clay industry is designed to cover that portion of the State where the refractory materials are produced.

An important matter in connection with the work of Geological Survey is to be in touch with the actual producers of the minerals within the State. In Pennsylvania there are over 11,000 producers of minerals, it is therefore, obviously impossible for the State Survey to know them personally, but in co-operation with the Division of Mineral Statistics of the United States Geological Survey in the collection of the figures of production a knowledge of the character, amounts and values of the various mineral products in the several portions of the State is being acquired and tabulated. An arrangement was made which was very favorable to the State and the output for the year 1911 is in process of collection. This necessarily involved a large amount of office work, especially during this, the first year of the work, but the results attained will be of great profit and advantage in carrying on the work of the Survey and in answering the numerous inquries which are constantly being received.

On another page of this report a short discussion of the output of the principal mineral products of the State will be found which will serve for comparison with the figures as determined in detail from the reports received during this year. The value of work such as this naturally increases from year to year with the securing of more perfect lists of producers and the value of their products.

One of the ways by which the relative importance of a Geological Survey to a State can be determined is by a study of the value of the mineral productions. The importance of the investigation of the minerals of a region primarily determines the economical value of geological work, but the quantity of the production of the minerals themselves determines the importance of technical study in preventing those wastes which are ever to be found and which are of greater importance in the low value, non-metalic minerals, than in the metals of greater intrinsic value.

Viewed in this way a Geological Survey is shown to be of far more value to the people of Pennsylvania than to any other State. This is true when we consider the gross value of the output, and it is equally true when we view the output of the State as compared with its area and with the number of its inhabitants.

For 1910 the total value of mineral products of the United States was more than $2,000,000,000. The area of the United States (excluding the Great Lakes and that portion of the oceans which are included in the *gross* area), is 3,026,789 square miles; therefore the average value of the mineral production was $661 per square mile of area.

The value of the production of the several states is shown by the following table, as also the area of each state.

Table Showing Mineral Production 1909-1910.

State.	Area sq. miles.	1909. Total value.	1909. Value per sq. mi.	1910. Total value.	1910. Value per sq. mi.
Alabama,	51,998	$41,982,208	$808	$47,751,109	$924
Arizona,	113,956	43,155,466	378	43,483,912	381
Arkansas,	53,335	5,889,329	111	5,350,705	101
California,	158,297	80,098,581	506	86,668,347	548
Colorado,	103,948	59,190,424	569	60,357,715	580
Connecticut,	4,965	3,480,918	701	3,505,161	706
Delaware,	2,370	876,501	369	664,073	272
Florda,	58,666	9,239,491	159	9,284,705	158
Georgia,	59,265	5,580,643	94	6,048,253	102
Idaho,	84,313	14,908,819	177	15,437,403	180
Illinois,	56,665	143,051,729	2,524	141,809,121	2,502
Indiana,	36,354	43,634,615	1,200	59,039,303	1,624
Iowa,	56,147	20,342,368	363	22,730,968	405
Kansas,	82,158	29,447,159	358	28,304,191	345
Kentucky,	40,598	16,857,148	417	21,512,982	530
Louisiana,	48,506	7,658,441	157	10,119,993	209
Maine,	33,040	4,376,488	136	4,713,123	143
Maryland,	12,327	12,881,574	1,045	15,440,207	1,255
Massachusetts,	8,266	6,779,974	820	6,077,370	735
Michigan,	57,980	55,041,671	950	47,771,775	824
Minnesota,	84,682	5,088,120	67	6,088,620	72
Mississippi,	46,865	1,129,639	24	840,152	12
Missouri,	69,420	50,416,043	728	52,640,054	758
Montana,	146,572	57,492,806	392	54,388,117	364
Nebraska,	77,520	1,509,318	21	1,552,794	20
Nevada,	110,690	29,628,326	267	34,617,127	312

Table Showing Mineral Production 1909-1910—Continued.

State.	Area sq. miles.	1909. Total value.	1909. Value per sq. mi.	1910. Total value.	1910. Value per sq. mi.
New Hampshire,	9,341	2,156,985	231	2,146,736	230
New Jersey,	8,224	29,626,329	3,603	30,888,892	3,756
New Mexico,	112,634	5,870,547	48	7,704,373	69
New York,	49,204	65,120,558	1,323	74,519,623	1,533
North Carolina,	52,426	2,551,918	49	2,616,131	42
North Dakota,	70,837	946,054	13	863,233	12
Ohio,	41,040	187,014,492	4,556	188,075,258	4,583
Oklahoma,	38,848	29,008,138	747	32,988,865	849
Oregon,	96,699	2,814,570	29	3,738,806	38
Pennsylvania,	45,126	549,860,811	12,185	591,602,573	13,110
Rhode Island,	1,248	1,203,878	964	800,503	641
South Carolina,	30,989	2,079,422	67	2,021,371	65
South Dakota,	77,615	7,604,487	99	6,093,434	79
Tennessee,	42,022	19,701,337	469	21,396,784	509
Texas,	265,896	17,214,068	65	18,383,451	69
Utah,	84,990	35,279,510	415	39,233,716	461
Vermont,	9,564	8,676,929	907	8,720,409	911
Virginia,	42,627	15,802,705	373	18,224,987	427
Washington,	69,127	15,483,886	224	16,809,080	243
West Virginia,	24,170	89,177,459	3,647	105,058,311	4,371
Wisconsin,	56,066	14,849,621	264	13,479,343	241
Wyoming,	97,914	10,332,939	106	12,110,286	124

If we examine these figures we find there are sixteen states in which the production per square mile of area exceeded the average of the whole country. This is shown in the following table, which gives the total production of these states for 1910; the average production per square mile and the percentage of the total of the United States produced by each of these states.

Production of Sixteen States, 1910.

	Total value of mineral production.	Value per sq. mile of area.	Percentage of total U. S.
Alabama,	$49,751,109	924	2.38
Connecticut,	3,505,161	706	.17
Illinois,	141,809,121	2,502	7.00
Indiana,	59,039,303	1,624	2.95
Maryland,	15,440,207	1,255	.77
Massachusetts,	6,077,370	735	.30
Michigan,	47,771,775	824	2.38
Missouri,	52,640,054	758	2.63
New Jersey,	30,888,892	3,756	1.54
New York,	74,519,623	1,533	3.72
Ohio,	188,075,258	4,583	9.39
Oklahoma,	32,988,865	849	1.64
Pennsylvania,	591,602,573	13,110	29.56
Rhode Island,	800,503	641	.04
Vermont,	8,720,409	911	.43
West Virginia,	105,058,311	4,371	5.25

The total production of these sixteen states was over $1,406,000,000, or 70 per cent. of the total of the United States.

The production of Pennsylvania was 29.56 per cent. of the whole or 40.09 per cent. of the output of these sixteen leading states.

A further analysis of these figures shows that eight states, all lying east of the Mississippi River, viz: Illinois, Indiana, Maryland, New Jersey, Ohio, Pennsylvania and West Virginia, each produced more than $1,000 of mineral wealth for each square mile of area, and that the total production of these eight states was more than $1,200,000,000 or 60 per cent. of the entire United States. Of this amount Pennsylvania produced one-half.

Pennsylvania not only far exceeds the output of other states but in conjunction with its adjoining states, New Jersey, New York, West Virginia, and Ohio, produced over one-half of the total mineral output of the entire United States. Thus again, the fact that Pennsylvania is the Keystone of the mining industry is brought home with force, and the diversity of its products is equally striking.

It is this great value of mineral wealth in the State that emphasizes the continual need of geological work, to properly illustrate its resources and make known its reserve. In 1885, Prof. J. P. Lesley, then State Geologist, in an address at Pittsburgh, pointed out that we were rapidly exhausting the Pittsburgh coal and showed that at the rate it was being mined and the rate of increase in the amount mined, it would last but a short time. The period then given was 80 years, or about 50 years hence. His actual figures give a somewhat shorter period, and it should be noted that the actual amount of coal being mined at the present time is larger than his estimated output, and hence the time of exhaustion is that much nearer.

Dr. I. C. White, in his address at the meeting of the governors in 1908 reiterated with force the fact that we were rapidly exhausting our resources. That a detailed and continuous study of the coals of the State will result in a vast saving in present wastes, and the mining of coals which now seem to be of little or no use, is recognized by all.

Another example of the need of geological study is the declining oil and gas production of the State. It is not to be supposed that any amount of study will bring the production of these fuels to its former magnitude, but it is certain that proper research will greatly aid in maintaining the output and save vast sums of money to those most interested—the State and its people.

It will not do to say that these studies should be made by those financially interested. It is true they may result in profit to those individuals but the private gain is small when compared with the profit to the people at large. Nor is it possible for such work to be done

by private enterprise; such studies must cover large areas and require the investigation of many producing properties and can only be made of value through comparison.

There is always more or less jealousy found among those engaged in the same kind of work, and all wish to keep private any detail by which others might profit. This inate feeling always results, to a greater or less degree, in the failure to secure in full the information needed when sought by individuals. When the work is done by the State this secretive instinct largely vanishes; the detailed data obtained by an official survey are not used for private gain; facts are freely given when they are to be used for the general good. But it is not the detailed facts which are needed for the published report. The general conclusions based on all the information, after it is carefully compared and adjusted, are the results sought, and it is these completed studies carried on over a large area, which prove of value to all interested and which mean an increased output at a decreased cost, with an increased feeling of good will among those engaged in the same industry.

Of the relation of the Geological Survey to the problems of conservation nothing need be said. Geological study is the foundation on which all matters pertaining to the possible savings in all mining industries depends.

Neither is it necessary to go into the details of the needs of the work now in progress. In the United States it is estimated that 65 per cent. of the business of all railroads is the direct result of the mining operations in the country. If this is so generally, a greater portion of the freights in Pennsylvania are thus derived. However we view it, the necessity of doing something to maintain the present output of mineral wealth is apparent; the entire prosperity of the State depends upon it.

RECOMMENDATIONS.

During the last two years the total appropriations for all the work of the Survey amounted to $25,000.

The apportionment of this fund was about as follows:

Salaries, including State Geologist and clerical work,	$8,600 00
Co-operative topographic work with the Federal Survey,	9,650 00
Co-operative mineral statistics, ...	500 00

Geological work, mapping, etc., reports issued and in progress, ...	4,100 00
General expenses of Commission, rental, express, traveling expenses, postage, etc., ...	2,150 00

It will readily be seen that with the utmost economy in conducting the various activities of the Survey in an attempt to meet the demands from many sections of the State, it is only possible to devote a small amount to the special reports on various economic subjects, and in no one case was there a sufficient sum of money available to engage the services of special assistants, trained for the work desired.

Hence your Commission was compelled to seek the co-operation of those who had already carried forward investigations in special lines, or who accepted the compensation offered to meet the expenses involved in the collection of data, rather than value for service performed.

This does not seem just to the associates who have performed valuable service, often at personal sacrifice, or at the sacrifice of the completeness of their work, neither does it seem fair to our Commission to expect good professional service upon any such basis of compensation.

Your Commission therefore recommends that more liberal appropriation be made for the continuance of the work of the Survey, now fairly well organized and prepared to carry forward both the geological and topographic investigations to best meet the demands of the people at large, and with results commensurate with the wealth of the State and the diversity and magnitude of its mineral industries.

This appropriation should:

First. Be sufficient to meet the largest possible sum the Federal Survey will allot for topographic work, that the mapping of the remaining half of the State may be completed as rapidly as possible. This will be about $25,000.

Second. To carry out the objects of the Survey in accordance with the Act of Assembly authorizing the establishment and maintenance of the same, the appropriation should be sufficient to take up and carry forward on broad lines the large geological problems, in order to increase the total mineral production of the State, reduce needless wastes in mining, lessen the danger to life accompanying mineral production, and result in fuller development of our mining industries. The funds needed for this work will include all salaries of the State Geologist and assistants, clerk hire, postage, telephone and telegraph, rent, traveling expenses, of the Commission, State Geologist, assistants and employes, express, freight, etc. To properly accomplish this work will require at least $25,000.

For these purposes therefore, we respectfully ask your co-operation, favorable recommendation and appropriation of not less than fifty thousand dollars ($50,000) for each of the next two fiscal years, a sum relatively far less than the appropriation made by any other State for similar work.

Respectfully submitted,

GEORGE W. McNEES,
ANDREW S. McCREATH,
EDWARD V. D'INVILLIERS,

APPENDIX A

LEGISLATIVE ACTS AND CONTRACTS.

AN ACT

Authorizing the Topographic and Geological Survey Commission of Pennsylvania to establish and maintain a topographic and geological survey of the State; fixing salaries; providing for the printing and binding of the results of said survey, and furnishing of supplies and stationery; and making an appropriation therefor.

Section 1. Be it enacted, etc., That the Topographic and Geological Survey Commission of Pennsylvania is hereby authorized to establish and maintain a topographic and geological survey of the State.

Section 2. The objects of such survey shall be as follows: The preparation and completion of a topographic map or maps of the State; also the study of its geological formations with special reference to the economic development of its resources, such as coal, ores, oil, gas, stones, cement material and all other minerals. With these ends in view, the said commission may, and is hereby authorized, to arrange with the United States Geological Survey, or such other National organization as may be authorized to do such work for its co-operation: Provided, That the amount of money to be expended in such co-operative work on behalf of the State shall not exceed the amount so expended by such National organization. The preparation of reports, with the necessary geological and other maps to properly illustrate the same, which shall be of such detail, character and style of publication as the said Commission may deem best suited to properly describe the resources of the State.

Section 3. The reports of the said survey shall be printed by the Department of Printing and Binding, in such form and style as may be designated by the Topographic and Geologic Survey Commission.

Section 4.. The said Commission shall serve without pay except the chairman of the same. He shall receive a salary of not more than fifteen hundred dollars per annum; and the necessary expenses of the said Commission shall be paid out of the State Treasury, after the same shall have been submitted in itemized form to the Auditor General and approved by him.

Section 5. The said Commission shall apoint a State Geologist, who shall be in immediate charge of the work of said survey, subject to the regulations and orders of said Commission. The said geologist shall receive a salary not to exceed three thousand dollars per annum. He may also appoint such assistants as in the judgment of such Commission may be proper and necessary.

Section 6. In addition to the reports hereinbefore authorized, the said Commission shall make a biennial report to the Governor and the Legislature, showing the progress and condition of the work, together with such other information and recomendations as the said Commission may deem necessary and useful.

Section 7. All specimens and material collected shall, after serving the purpose of the survey, be deposited in the State Museum, and there preserved in such form as to be available for study in the further work of the survey, or by individual students; but must not be removed from said museum except for study and use by the State Geologist or those working under his directions.

Section 8. All supplies or stationary, blank books, forms or other printed matter necessary for the use of said survey, shall be furnished by the Department of Printing and Binding or the Department of Public Grounds and Buildings, upon the requisition of said Commission.

Section 9. It shall be lawful for any and all persons employed in carrying on the work of the said survey to enter upon and cross all lands within the State; Provided, That in so doing no damage shall be done to private property.

Section 10. The sum of twenty thousand dollars annually, for the term of two years, is hereby appropriated for the use of said Commission in carrying on the work authorized by this act.

Section 11. This act shall be in effect on the first day of June, Anno Domini nineteen hundred and nine.

Section 12. All laws or parts of laws inconsistent with this act are hereby repealed.

Approved—The thirteenth day of May, Anno Domini one thousand nine hundred and nine, in the sum of $10,000 annually for the term of two years. I withhold my approval from the remainder of said appropriation because of insufficient State revenue.

EDWIN S. STUART.

AGREEMENT.

Between the Topographical and Geological survey Commission of the State of Pennsylvania and the Director of the United States Geological Survey, for the Co-operative Topographic and Geologic Survey of the State.

1. The preparation of the maps shall be under the supervision of the Director of the United States Geological Survey, who shall determine the methods of survey and map construction, in accordance with the act of Assembly of the State of Pennsylvania, entitled "An act to authorize the topographic and geologic survey of the State in co-operation with the United States Geological Survey," approved April 28, 1899.

2. The order in which in point of priority different parts of the State shall be surveyed shall be agreed upon in detail between said Commission and said Director.

3. The work shall be based upon the triangulation of the United States Coast and Geodetic Survey, and, wherever this triangulation is deficient, it shall be supplemented by said co-operative survey.

4. The survey shall be executed in a manner sufficiently elaborate to prepare a topographic map upon the scale of 1:62,500 exhibiting the hydrography, hypsography and the public culture; said survey and map shall accurately show all township and county boundary lines (as established by the State laws at the time of their completion), and extensive wooded areas in this State as existing on the ground at the time of the execution of these surveys; the location of all roads, railroads, streams, canals, lakes and rivers, and shall show by contour lines the elevation and depression of the surface of the country, also on geologic maps the location of the coal, oil, natural gas, clay-bearing and other geological formations. The said topographic maps shall be similar to the sheets already completed in this State, and the form of the final publications of the geological map shall be the same as the Geological Atlas of the United States Geological Survey.

The primary field maps shall be on such a scale as said Director shall select to secure accuracy in the construction of the final map.

5. It is understood and agreed upon that the geological work shall follow the topographic survey as closely as consistent with economy and in accordance with modern scientific methods. The time of beginning this work to be agreed upon between the State Survey Commission of Pennsylvania and the United States Geological Survey.

6. The hypsography shall be shown by contour lines with vertical intervals of 20 feet, and the heights of important points shall be determined and marked upon fixed and permanent bench marks in

important and prominent places throughout the counties; also correct meridian points shall be located at each county seat and records furnished to the said Commission.

7. For convenience, the United States Geological Survey shall, during the progress of the field work, pay the salaries of the persons employed therein, while the traveling, subsistence and field expenses shall be paid for the same by the State. For office work on the map the salaries shall be divided between the two agreeing parties in such a way as to equalize all expenses, provided that the total cost to the State of Pennsylvania of the field and office work and expense of said Commission for the year 1899 and 1900 shall not be more than forty thousand dollars ($40,000), and provided that the United States Geological Survey shall expend an equal amount.

8. During the progress of the work free access to the field sheets and records of the topographers and draughtsmen shall be afforded the State Commisisoners for examination and criticism; and should they deem that the work is not being executed in accordance with this agreement, then the said Commissioners may, on formal notice, terminate this agreement.

9. The resulting maps shall fully recognize the co-operation of the State of Pennsylvania.

10. As the work is completed, the State Commission shall be furnished by the United States Geological Survey with photographic copies of the manuscript sheets; and, when the engraving, which is to be done at the cost of the United States Geological Survey, is completed, and at all times thereafter, when desired, the said Commission shall be furnished by the said Survey with transfers at cost of printing from the copper plates of the photographic sheets for use in printing editions of said maps.

Washington, D. C., July 12, 1899.

(Signed) CHAS. D. WALCOTT,
Director U. S. Geological Survey.

G. W. McNEES,
SIMON HARROLD,
FRED. D. BARKER,
Topographic Survey Commissioners,

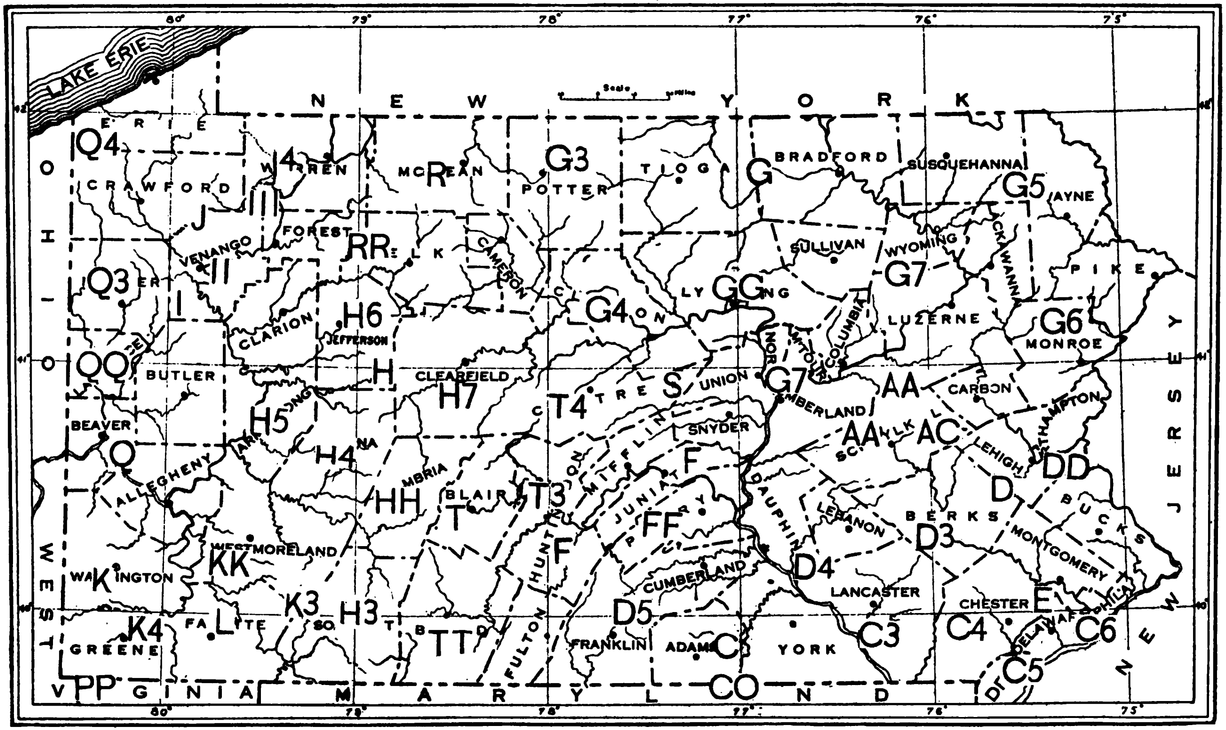

Plate IV. Key map showing areas covered by publications of the Second Geo logical Survey of Pennsylvania.

APPENDIX B

PUBLICATIONS OF THE PENNSYLVANIA SURVEYS AND OF THE UNITED STATES GEOLOGICAL SURVEY RELATING TO PENNSYLVANIA.

First Geological Survey.

None of the reports of this survey are available for distribution. They have long been out of print and can only be had from dealers in second hand books.

Second Geological Survey.

The reports of this survey are also out of print and neither the present survey nor other department of the State Government has the same for distribution. For convenience the following list of the publications of the Second Geological Survey, and Index Map showing the area covered by each is here given. The reports can generally be had from dealers in second hand books.

Annual Reports.

1885—769 pp. 8 pl., with Atlas, contains following special reports:

1. Oil and Gas. John F.F Carll.
2. Vegetable Origin of Coal. Leo Lesquereux.
3. Pittsburg Coal Region. E. V. d'Invilliers.
4. Wellersburg Coal Basin. J. P. Lesley and E. B. Harden.
5. Tipton Run Coal Basin. C. A. Ashburner.
6. Anthracite Coal Region. C. A. Ashburner.
7. Wyoming Valley Fossils. C. A. Ashburner and A. Heilprin.
8. Bernice Coal Basin. C. A. Ashburner.
9. Mehoopany Coal Field. F. A. Hill.
10. Cornwall Ore Mines. J. P. Lesley and E. V. d'Invilliers.
11. Delaware and Chester Kaolins. J. P. Lesley and C. A. Ashburner.
12. Quarternary Geology, Wyoming Valley. C. A. Ashburner, F. A. Hill and H. C. Lewis.
13. Pressure, &c., of Rock Gas. J. P. Lesley.
14. Progress Geodetic Survey. Mansfield Merriman.

1886—4 parts as follows:

i. Pittsburgh Coal Region. E. V. d'Invilliers.

ii. Oil and Gas Region. J. F. Carll, F. C. Phillips, B. S. Lyman.

iii. Anthracite Coal Region with Atlas. F. A. Hill.

iv. 1. The Lehigh River Cross Section. Arthur Winslow.

2. Point Ores Along the Lehigh River. F. A. Hill.

3. Iron Ore Mines and Limestone Quarries of the Cumberland-Lebanon Valley. E. V. d'Invilliers.

4. Geology of Radnor Township, Delaware Co., &c., T. D. Rand. With an Atlas.

1887—105 pp. map New Boston Anthracite Basin.

1. Cave Fossils. Prof. Joseph Leidy.

2. Fossil Tracks in the Trias. Atreus Wanner.

3. New Boston Anthracite Basin. Benj. Smith Lyman.

4. State Line Serpentine. Prof. F. D. Chester.

Miscellaneous Reports.

A. A History of First Geological Survey of Pennsylvania, from 1836 to 1858, J. P. Lesley; with annual reports of Board to Legislature for 1874 and 1875. 226 pp. 1876.

B. Minerals of Pennsylvania, F. A. Genth; hydro-carbon compounds, S. P. Sadtler; reference map. 206 pp. 1875.

B2. Minerals, F. A. Genth, continued from page 207 to 238. 31 pp. 1876. (Bound with B.)

M. Chemical Analyses in 1874-5, A. S. McCreath. 105 pp. 1875.

M2. Chemical Analyses in 1876-8, A. S. McCreath; Classification of coals, P. Frazer; Fire-brick tests, F. Platt; Dolomitic limestone Beds, J. P. Lesley; Utilization of Anthracite Slack, F. Platt; Determination of Carbon in Iron or Steel, A. S. McCreath. 1 folded pl., 4 page pls. 438 pp. 1879.

M3. Chemical Analyses in 1879-80, A. S. McCreath; reference map of 93 iron ore mines in Cumberland Valley. 126 pp. 1881.

N. Levels above tide of railroads, canal and turnpike stations, mountain tops, &c., in and around Pennsylvania, 200 tables, C. Allen; map. 279 pp. 1878.

O. Catalogue of specimens collected by survey (No. 1 to 4,264), C. E. Hall. 217 pp. 1878.

O2. Catalogue (continued from No. 4,265 to No. 8,974); also catalogue of fossils (pp. 231 to 239). 272 pp. 1880.

O3. Catalogue (continued from No. 8,975 to No. 12,872); also catalogue of special collections of fossils in stratigraphical order, from 201-1 to C7-4-3; and Revised Catalogue of Randall's collection, from 9,467 to 9,625. 260 pp. 1889.

P. Coal Flora of Pennsylvania and the United States. Vols. 1 and 2 (bound together), L. Lesquereux. 694 pp. 1880.

P. Coal Flora of Pennsylvania and the United States. Vol. 3, 24

double page pls, (lithographed) of coal plants, to accompany P., vols. 1 and 2. 283 pp. 1884.

(P). Atlas of 87 double page pls. (lithographed) of coal plants to accompany P., vols. 1 and 2. 1879.

P2. Permo-Carboniferous plants from W. Va. and Greene county, Pa., W. M. Fontaine and I. C. White. 38 double page pls. (lithographed). 143 pp. 1880.

P3. Ceratiocaridae, C. E. Beecher; Eurypteridae, James Hall. 8 pls. 39 pp. 1884.

P4. Dictionary of Fossils found in Pa. and elsewhere, with electrotype illustrations of the various forms. 2 vols and appendix, J. P. Lesley. pp. 800. 1889.

X. Geological Hand Atlas of the 67 counties of Pa., with short explanation of the geological structure of each county, embodying results of field work of the survey from 1874 to 1884, J. P. Lesley. 62 colored maps and cross section. 112 pp. 1885.

Z. Terminal Moraine across Pennsylvania, H. C. Lewis; extracts from descriptions of the Moraine in New Jersey, G. H. Cook, and in Ohio, Kentucky and Indiana, G. F. Wright. Map of State, 18 photographic views of the Moraine, and 32 page plate maps and sections. pp. lvi and 299. 1884.

Grand Atlas, Div. I, Pt. I, 1885, port-folio containing maps of 56 counties and parts of counties (scale 2 mi. to 1 inch) on 49 sheets (26″ x 32″).

Annual Report, Pt. IV, 1886.

Anthracite Region.

A2. Causes, kinds and amount of waste in mining anthracite, F. Platt; Methods of mining (1 chapter), J. P. Wetherill, illustrated by 35 figures of mining operations, plan of the Hammond breaker, and specimen sheet of the maps of the anthracite coal fields, 134 pp. 1881.

AC. Mining Methods, &c., in the anthracite coal fields, H. M. Chance. 54 pls. and 60 illustrations in text. 574 pp. 1883. Atlas containing 25 pls. illustrating coal mining.

AA. First report of progress of the anthracite survey; Panther Creek Basin, C. A. Ashburner; determination of the latitude and longitude of Wilkes-Barre and Pottsville, C. L. Doolittle; theory of stadia measurements, A. Winslow. 407 pp. 1883.

AA. Second report of progress of the anthracite survey, Pt. I; Statistics of Production and Shipment for 1883 and 1884, C. A. Ashburner.

(AA). Atlas of Southern anthracite coal field, Pt. I, 13 sheets; 3 geographical and mine sheets, 3 cross section sheets, 3 columnar section sheets, 1 topographical map sheet, and 1 coad bed area sheet, relating to the Panther Creek Basin; 1 general map of the anthracite

region, and 1 chart of anthracite production from 1820 to 1881; C. A. Ashburner, A. W. Sheafer and F. A. Hill. 1882.

(AA). Atlas Southern anthracite field, Pt. II, 13 mine sheets between Tamaqua and Tremont, F. A. Hill and A. D. W. Smith. 1889.

(AA). Atlas Southern anthracite field, Pt. III, 12 mine sheets between Tremont and western end of the southern basin, and a general map of the anthracite fields showing the location of collieries. F. A. Hill and A. D. W. Smith. 1889.

(AA). Atlas Southern anthracite field, Pt. IV. 2 vols.

(AA). Atlas Southern anthracite field, Pt. V.

(AA). Atlas Southern anthracite field, Pt. VI.

(AA). Atlas of Western Middle anthracite field, Pt. I, 11 sheets; 4 geological and mine sheets between Delano and Locust Dale, 3 topographical sheets between Quakake Junction and Mount Carmel, and 4 cross section sheets. C. A. Ashburner, A. W. Sheafer and Bard Wells. 1884.

(AA). Atlas of Western Middle anthracite field, Pt. II, 11 sheets; 4 geological and mine sheets from Mount Carmel to the western end of the coal field, and 7 columnar section sheets covering the entire field. F. A. Hill and Bard Wells. 1887.

(AA). Atlas of Western Middle anthracite field, Pt. III.

(AA). Atlas of Northern anthracite field, Pt. I, 6 geological and mine sheets between Wilkes-Barre and Nanticoke, 3 cross section sheets and 4 columnar section sheets, C. A. Ashburner and F. A. Hill. 1885.

(AA). Atlas of Northern anthracite field, Pt. II, 10 sheets; 4 mine sheets relating to that portion of the Wyoming-Lackawanna coal basin between Wyoming and Taylorville, and 2 topographical and mine sheets relating to the extreme western end of the Wyoming basin; 4 columnar section sheets of boreholes, shafts, and tunnels; F. A. Hill and William Griffith. 1887.

(AA). Atlas of Northern anthracite field, Pt. III, 8 sheets; 4 mine and 4 columnar section sheets relating to that portion of the Lackawanna basin in the vicinity of Taylorville, Minooka, Scranton, Dunmore and Priceville; F. A. Hill and William Griffith. 1889.

(AA). Atlas of Northern anthracite field, Pt. IV, 8 mine sheets relating to that portion of the Lackawanna basin in the vicinity of Olyphant, Peckville, Jessup, Winton, Archbald, Jermyn, Glenwood, Carbondale, and Forest City in Lackawanna and Susquehanna counties; F. A. Hill and William Griffith. 1889.

(AA). Atlas of Northern anthracite field, Pt. V.

(AA). Atlas of Northern anthracite field, Pt. VI.

(AA). Atlas Eastern Middle anthracite field, Pt. I, 8 sheets; 2 geological and mine sheets in the vicinity of Hazleton, Drifton and

surrounding towns, 3 cross section sheets and 3 columnar section sheets; C. A. Ashburner, A. P. Berlin and Arthur Winslow. 1885.

(AA). Atlas of Eastern Middle anthracite field, Pt. II, 8 sheets; 6 mine and 2 columnar section sheets relating to portions of the Lehigh basins in the vicinity of Upper Lehigh, Pond Creek, Sandy Run, Eckley, Weatherly, Buck Mountain, Beaver Meadow, Coleraine, Jeansville and Audenried, in Luzerne, Carbon and Schuylkill counties; F. A. Hill and I R. Moister. 1888.

(AA). Atlas Eastern Middle anthracite field, Pt. III, 13 sheets; 8 mine sheets, covering the entire western part of the field, 2 columnar section sheets and 3 cross section sheets; F. A. Hill and I. R. Moister. 1889.

Grand Atlas, Div. II, Pt. I. 1884. Port-folio containing 26 sheets (26″ x 32″), as follows: 13 sheets Atlas Southern Anthracite Field, Pt. I, 11 sheets Atlas Western Middle Anthracite Field, Pt. I, 1 sheet photo views of plaster models in Western, Middle and Southern Fields, and 1 specimen sheet, Report A2.

Grand Atlas, Div. II, Pt. II, 1885. Port-folio containing 22 sheets (26″ x 32″), as follows: 13 sheets Atlas Northern Anthracite Field, Pa. 1, 8 sheets Atlas Eastern Middle Anthracite Field, Pt. I, and 1 sheet containing a preliminary general map of the Anthracite Coal Fields and adjoining counties.

For anthracite coal in Sullivan county, see G2 and Annual Report, 1885.

For Utilization of anthracite slack, see M2.

For general description anthracite region, Quaternary Geology of the Wyoming-Lackawanna Valley, &c., &c., see Annual Report, 1885.

Annual Report, Pt. III. 1886.

Bituminous Coal Fields and Surrounding Areas.

H. First report on Clearfield and Jefferson counties, F. Platt. 8 maps, 2 sections, 139 cuts in text. 296 pp. 1875. (For second report, see H 6, H 7.)

H 2. Cambria county, F. & W. G. Platt. 4 maps and sections, and 84 cuts in text. 194 pp. 1877.

H 3. Somerset county, F. & W. G. Platt. 6 maps and sections and 110 cuts in text. 348 pp. 1877.

Atlas to Reports H2 and H3 containing geological maps of Cambria and Somerset counties, with 2 sheets of columnar sections and 1 cross section; a revision and correction of the semi-bituminous coal section at Wellersburg, Somerset county, and notes on the new mines in Cambria county. 1889.

H 4. Indiana county. W. G. Platt. Colored geological map and 87 cuts in text. 316 pp. 1878.

H 5. Armstrong county, W. G. Platt. Colored geological map and 58 cuts in text. 338 pp. 1880.

H 6. Jefferson county, W. G. Platt. Colored geological map and 57 cuts in text. 218 pp. 1881.

H 7. Clearfield county, H. M. Chance. Colored geological map, an outcrop map of Houtzdale basin, and 58 cuts in text. 197 pp. 1884.

I &. Venango county, J. F. Carll; The geology around Warren, F. A. Randall; Notes on the comparative geology of N. E. Ohio, N. W. Pa., and WW. New York, J. P. Lesley. 1 small map of the Venango oil region, 1 small map of the region south and east of Lake Erie, 1 long section of the rocks at Warren, and 7 cuts in text. 127 pp. 1875.
section of the rocks at Warren, and 7 cuts in text. 127 pp. 1875.

I 2. Oil well records and levels in Venango, Warren, Crawford, Clarion, Armstrong, Butler, &c., J. F. Carll. 398 pp. 1877.

I 3. Venango, Warren, Clarion and Butler Oil Regions; descriptions of rig, tools, &c., survey of the Garland and Panama conglomerates, &c.; discussion of pre-glacial and post-glacial drainage; J. F. Carll. 23 page plates and an atlas. 482 pp. 1880.

(I 3.), Atlas of 22 sheets. Map of Venango county, colored geologically; map lower oil field (Butler, Armstrong and Clarion) in two sheets; 3 local contour maps at Franklin, Titusville and Spring Creek; 2 maps of N. W. Pennsylvania, showing past and present drainage; long section across W. Pennsylvania; vertical section of the formations from the Upper Coal measures down to the bottom of the Devonian; diagram map and section of Third sand; profile section from Meadville, S. W.; 5 sheets of grouped oil well sections; 5 sheets of working drawings for well boring, &c.; diagram of daily rate of drilling six wells at Petrolia.

I 4. Warren county, J. F. Carll. Colored geological map, map of Warren oil region, and 2 sheets of oil well sections. 439 pp. 1883. (Note—The first 147 pages of this book contain oil well records.)

I 5. Seventh report of the oil and gas fields, for 1887, 1888. 356 pp. 1890.

J. The Oil Region, H. E. Wrigley; map and profile of line levels through Butler, Armstrong and Clarion, D. J. Lucas; map and profile of Slippery Rock creek, J. P. Lesley. 5 maps and sections, 1 pl. and 5 cuts. 122 pp. 1875.

K. Greene and Washington counties, J. J. Stevenson. 2 maps. (Showing the calculated local depths of the Pittsburg and Waynesburg coal beds beneath the surface), 3 page plates of general sections. 419 pp. 1876. (Note—Since publication of this book two colored geological county maps have been published, and will be found in pocket of vol. K3.)

K 2. First report on Fayette, Westmoreland and S. E. Allegheny

counties (i. e., west of Chestnut Ridge), J. J. Stevenson. 3 colored geological maps and 50 cuts in text. 437 pp. 1877.

K 3. Second report on Fayette and Westmoreland counties (the Ligonier Valley), J. J. Stevenson. 4 page plates and 107 cuts in text. 331 pp. 1878.

K 4. Monongahela River Coal Mines, from West Virginia State Line to Pittsburgh (including some of the Youghiogheny and other streams), J. Sutton Wall. Map of region in pocket, 12 heliotype pictures, 26 page plates. 231 pp. 1884.

L. Youghiogheny coke manufacture, F. Platt; Notes on the coal and iron ore beds, C. A. Young; Report on methods of coking, J. Fulton; Report on the use of natural gas in the iron manufacture, J. B. Pearse and F. Platt; The Boyd's Hill gas well at Pittsburgh, J. P. Lesley. Map of the coke region, two folded plates of coke ovens, and page plates and cuts in text. 252 pp. 1876.

Q. Beaver, N. W. Allegheny and S. Butler counties, I. C. White. 3 colored geological county maps, and 21 page plates of sections. 337 pp. 1878.

Q 2. Lawrence county, and special Report on Correlation of the Pennsylvania and Ohio coal beds, I. C. White. Colored geological map (county) and 134 cuts in text. 336 pp. 1879.

Q 3. Mercer county, I. C. White. Colored geological county map and 119 cuts in text. 233 pp. 1880.

Q 4. Crawford and Erie counties, I. C. White. 2 colored geological county maps and 107 cuts in text. Also, report on a pre-glacial outlet for Lake Erie, J. W. Spencer. 2 maps of the Lake region. 406 pp. 1881.

R. McKean county, and its geological connections with Cameron, Elk and Forest counties, C. A. Ashburner. 33 page plates of vertical and columnar sections, pictures of Rock City and Olean conglomerate, Wilcox and Kane spouting wells, map of Howard Hill coal field, &c., and an atlas of 8 sheets. 371 pp. 1880.

(R.) Atlas for McKean county of 8 sheets; colored geological county map; 3 topographical maps; Buffalo Coal Company tract, Alton coal basin, and Potato Creek coal basin; map of McKean oil district; one sheet of colmunar sections between Bradford and Ridgway and 2 diagram sheets of the Well account and Production account in the Bradford district.

R 2. Pt. II, report on township geology of Cameron, Elk and Forest counties, C. A. Ashburner.

(R 2.) Atlas for Cameron, Elk and Forest counties, of 11 sheets (published November, 1884, in advance of the report); 3 colored geological county maps; 1 anticlinal and synclinal map; 1 topographical map McKean county; 2 tract maps Forest and Elk counties; 1 map

Straight Creek coal basin; 2 sheets oil well sections; and 1 sheet coal sections.

V. N. Butler county; and (Pt. II) special report on the Beaver and Shenango river coal measures, H. M. Chance. Colored geological map of N. Butler; contour local map around Parker; map of the anticlinal rolls in the 6th basin; chart of the Beaver and Shenango rivers; profile sections from Homewood to Sharon; oil well records and surface sections; and 154 cuts in text. 248 pp. 1879.

V 2. Clarion county, H. M. Chance. Colored geological county map; map of the anticlinals and oil belt; contoured map of the old river channel at Parker; 4 page plates, and 83 cuts in text. 232 pp. 1880.

For the coal basins of Bradford and Tioga counties, see report G.

For the coal basins of Lycoming and Sullivan, see report G 2.

For the coal basins of Potter county, see G 3.

For the coal basins of Clinton county, see G 4.

For the coal in Wayne county, see G 5 and Northern Atlas, Part IV.

For the East Broad Top coal basin in Huntingdon county, see F.

For the mountain coals in Blair county, see T.

For the Broad Top coal measures in Bedford and Fulton counties, see T 2.

For the coal basins in Centre county, see T 4.

For coal analyses, see M, M 2, M 3.

For clasifications of coals, see M 2.

For coal plants, see P. P 2.

For fossil crustaceans in coal slate, see P 3.

For origin of coal; Pittsburg Region and Monongahela Valley; Wellersburg coal basin, Somerset county; and Tipton Run coal beds, Blair county; see Annual Reports, 1885, and Atlas H 2 and H 3 .

Grand Atlas, Div. III, Pt. I, 1885; port-folio containing 35 sheets (26″ x 32″), as follows: 32 sheets relating to portions of the Petroleum and Bituminous Coal Fields, and 3 sheets relating to the Quaternary period.

Annual Report, 1886. Part I.

Petroleum and Gas.

See reports I, I 2, I 3, I 4, and J, under Bituminous Coal Fields.

See L for the Pittsburgh gas well, and the use of gas in iron manufacture.

See Q, Q 2, Q 3, Q 4, for references to oil rocks in Beaver, Lawrence, Mercer, Crawford, Erie and S. Butler counties.

See K for the Dunkard Creek oil wells of Green county.

See R, R 2, for descriptions of oil rocks in McKean, Elk and Forest counties.

See V, V 2, for notes on the oil rocks of N. Butler and Clarion counties.

See H 2 for oil boring at Cherry Tree, Cambria county.

See G 5 for oil boring in Wayne county.

See Annual Report, 1885, for report of progress in the oil and gas region, with special facts relating to the geology and physics of natural gas.

See Grand Atlas, Div. III, Pt. I, under Bituminous Coal Fields.

See Annual Reports, 1886. Part II.

Northeastern and Middle Pennsylvania.

(Palaeozoic formations from the Coal Measures down.)

D. First report on Lehigh county iron mines, F. Prime. Contour line map of the ore region and 8 page plates. 73 pp. 1875.

D 2. Second report on Lehigh county iron mines, F. Prime. Colored geological contour line map of the iron region (in 4 sheets), colored geological contour line map of the Ironton mines, 4 double page litograph pictures of Limestone quarries, and 1 page plate of Monocraterion. 99 pp. 1878.

D 3. Vol. I. Lehigh and Northampton counties. Introduction by J. P. Lesley; Slate belt, R. H. Sanders; Limestone belt and iron mines, F. Prime; South Mountain rocks, F. Prime and C. E. Hall. 3 lithograph pictures of quarries, 4 pictures of triangulation stations, 14 page plates of sections, and an atlas of maps. 283 pp. 1883. (Note—For atlas, see below.)

D 3. Vol. II. Berks county (South Mountain belt), E. V. d'Invilliers. 10 pages plates of sections and Indian relics, and 3 pictures of rock exposures. 441 pp. 1883. (Note—For atlas, see below.)

(D 3.) Atlas; 1 colored geological map of Lehigh and Northampton counties (1 sheet); 1 colored geological contour line map of southern Northampton county (6 sheets); a contour line map of the mountains from the Delaware to the Schuylkill (18 sheets); colored geological contour line index map to the 22 sheets (1 sheet); and 4 sheets of maps of iron mines.

(D 5) Atlas of colored geological county maps of Cumberland, Franklin and Adams (3 sheets); and first installment of contour line map of the South Mountains, Sheets A 1, A 2, B 1, B 2 (4 sheets), A. E. Lehman.

(D 6) Atlas, South Mountain, continued.

F. Juniata River district in Mifflin, Snyder, and Huntingdon counties, J. H. Dewees; The Aughwick Valley and East Broad Top region in Huntingdon county, C. A. Ashburner. Colored geological maps of East Broad Top R. R. and Orbisonia vicinity (2 sheets);

Three Springs map and section (2 sheets); Sideling Hill Creek map and section (2 sheets), and Isometric projection at Three Springs (1 sheet); six folded cross sections, and 22 page plates of local maps and columnar sections. 305 pp. 1878.

F 2. Perry county (Pt. I, geology), E. W. Claypole. 2 colored geological maps of the county; 17 geological outline township maps as page plates, and 30 page plate cross and columnar sections. 437 pp. 1884.

F 3. Union, Snyder, Mifflin and Juniata counties, with descriptions of the Clinton Fossil Ore mines, Monellus Carbonate ore mines and Lewistown Limestone Quarries by E. V. d'Invilliers. Colored geological maps of Union and Snyder and of Mifflin and Juniata counties. 420 pp. 1891.

(F 3). Atlas, contour map and section Greenwood Furnace, contour map and section Monroe Furnace, contour geological map of Stone Mountain Fault, contour geological map of parts of Huntingdon, Mifflin, Centre and Union counties. Geological map of parts of Jackson and Barre townships. Cross sections of Seven Mountains.

G. Bradford and Tioga counties, A. Sherwood; report on their coal fields (including forks of Pine Creek in Potter county), F. Platt; report on the coking of bituminous coal, J. Fulton. (See L above). 2 colored geological county maps, 3 page plates, and 35 cuts in text. 271 pp. 1878.

G 2. Lycoming and Sullivan counties; field notes by A. Sherwood; coal basins by F. Platt. 2 colored geological county maps (of Lycoming and Sullivan); topographical map (in 2 sheets) of the Little Pine Creek coal basin; and 24 page pates of columnar sections. 268 pp. 1880.

G 3. Potter county, A. Sherwood; report on its coal fields, F. Platt. Colored geological county map, 2 folded plates and 2 page plates of sections. 121 pp. 1880.

G 4. Report on Clinton county, H. M. Chance, including description of the Renovo coal basin, C. A. Ashburner, and notes on the Tangascootac coal basin, F. Platt. Colored geological county map, 1 sheet of sections, local Renovo map, 6 page plates and 21 sections in text. 183 pp. 1880.

G 5. Susquehanna and Wayne counties, I. C. White. Colored geological map of the two counties and 58 cuts in text. 243 pp. 1881.

G 6. Pike and Monroe counties, I. C. White. 2 colored geological county maps (1 sheet Pike and Monroe and 1 sheet Wyoming); map of glacial scratches, and 7 small sections. Report on the Delaware and Lehigh Water Gaps, with two contoured maps and five sections of the gaps, H. M. Chance. 407 pp. 1882.

G 7. Wyoming, Lackawanna, Luzerne, Columbia, Montour and Northumberland counties (i. e., the parts lying outside of the anth-

racite coal fields), I. C. White. Colored geological map of these counties (in 2 sheets), and 31 page plates in text. 464 pp. 1883. (Note—The colored geological map of Wyoming county is published in G 6.)

T. Blair county, F. Platt. 35 cuts in text and an atlas of maps and sections (see below). 311 pp. 1881.

(T) Atlas of colored geological contour line map of Morrison's Cove, Canoe Valley, Sinking Valley and country west to the Cambria county line (14 sheets); index map of the same (1 sheet); colored sections (2 sheets). 1881.

T 2. Bedford and Fulton counties, J. J. Stevenson. 2 colored geological maps of the two counties. 382 pp. 1882.

T 3. Huntingdon county, I. C. White. Colored geological map of the county, and numerious sections. 471 pp. 1885.

T 4. Centre county, E. V. d'Invilliers; also special report, A. L. Ewing, and extracts from report to Lyon, Shorb & Co., by J. P. Lesley, Colored geological map of the county, 13 page plates of local maps and sections, and 15 cuts in text. 464 pp. 1884.

For report on line of the Terminal Moraine, see Z.

Grand Atlas, Div. IV, Pt. I, 1885. Port-folio containing 43 sheets, as follows: 30 sheets relating to the Durham and Reading Hills and bordering valleys in Northampton, Lehigh, Bucks and Berks counties, and 13 sheets relating to the South Mountains in Adams, Franklin, Cumberland and York counties.

Grand Atlas, Div. V, Pt. 1, 1885. Port-folio containing 35 sheets, as follows: 29 sheets relating to the Topography and Geology of the Palaeozoic strata in parts of Cambria, Blair, Bedford, Huntingdon, Mifflin, Centre and Union counties, 5 sheets containing map and geological cross section along the east bank of the Susquehanna River, Lancaster county, and 1 sheet containing cross sections of the Philadelphia belt of the Azoic rocks.

For report on Cornwall Iron Ore Mines, Lebanon county, and the Tipton Run coal beds, Blair county, see Annual Report, 1885.

For report on the Iron Ore Mines and Limestone Quarries of the Cumberland-Lebanon Valley, and Paint-ore along the Lehigh River, see Annual, 1886, Part IV.

Southeastern Pennsylvania.

C. York and Adams counties, P. Frazer. 1 folded map of a belt of York county through York and Hanover, 6 folded cross sections, and 2 page plate microscopic slices of dolerite. 198 pp. 1876. (Note—The colored geological county map of York is published in the Atlas to C 3.)

C 2. York and Adams counties (South Mountain rocks, iron ores, etc.), P. Frazer. 1 general map of the district, 10 folded cross sections, and 5 page plates. 400 pp. 1877. (Note—The colored geological county map of Adams is published in D 5.)

C 3. Lancaster county, P. Frazer. 9 double page lithographic views of slate quarries and Indian-pictured rocks; 1 plate of impressions on slate, and 1 page plate microscopic section of trap, and an atlas. 350 pp. 1880.

(C 3) Atlas of 13 sheets: Colored geological map of York county; colored geological map of Lancaster county; Susquehanna River section. (Sheets 1, 1A, 2, 2A, 3, 4); Lancaster section; Pequea section; Muddy Run section; Chestnut Hill mines; Gap Nickel mine.

C 4. Chester county; general description, 214 pp., J. P. Lesley; Field notes on the townships, 139 pp., P. Frazer. Colored geological county map, photographic view of contorted schists, and 12 page plates. 394 pp. 1883.

C 5. Delaware county, C. E. Hall. Colored geological county map; 30 photographic page plate views of granite quarries, kaolin pits, etc., and 4 page plates of altered mica. 128 pp. 1885. See Annual Report, 1885, for Kaolin report.

C 6. Philadelphia and the southern parts of Montgomery and Bucks counties, C. E. Hall. Colored geological map of the belt of country between Trenton and Delaware county (in 3 sheets), a sheet of colored cross sections and 24 cuts in text. 145 pp. 1882.

(C 7) Atlas to report on Bucks and Montgomery counties, containing 12 sheets of topographical map of the Neshaminy, Tohickon and Perkiomen water basins by the Philadelphia Water Department on a scale of 1,600 feet to 1 inch, 1-19600 of nature. 1887.

E Part I (historical introduction to) of a report on the Azoic rocks, T. S. Hunt. 253 pp. 1878.

For report on the koalin deposits of Chester and Delaware counties, see Annual Report, 1885.

For report on the Serpentines of Radnor township, Delaware Co., etc., see Annual, 1886, Part IV.

See also Grand Atlas, Div. V, Pt. I, under Northeastern and Middle Pennsylvania.

Summary Report.

Vol. I. Laurentian, Cambrian, Lower Silurian. J. P. Lesley, pp. 1-719, 1892.

Vol. II. Upper Silurian and Devonian. J. P. Lesley, pp. 721-1628, 1893.

Vol. III, part 1. Carboniferous. J. P. Lesley, E. V. d'Invilliers, and A. D. W. Smith, pp. 1629-2152, 1895.

Vol. III, part 2. Carboniferous, New Red. E. V. d'Invilliers and Benjamin Smith Lyman, pp. 2153-2638, 1895.

Atlas, Final Summary Report.

These volumes give in a condensed form a summary of practically all of the preceding publications, with some additional matter of later date, including a new geologic map of the State, a map and list of bituminous mines, and 611 page plates.

Index of Final Summary Report, Wm. A. Ingham, pp. 1-98, i-xxx, 1895.

TOPOGRAPHIC AND GEOLOGIC SURVEY.

General Reports.

Report of 1899 and 1900. A report of 135 pages with a progress map of the State, showing the results of topographic work and also of the Co-operative Geological Work.

Report of 1899-1906. A report of 308 pages with an index map of the Topographic and Co-operative Geologic Work in the State. Contains a list of positions in the State determined by triangulation and by primary traverse; a list and a description of meridian lines and magnetic determinations by the United States Geological Survey and by the Coast and Geodetic Survey; a list of determined elevations within the State, and a list of published topographic atlas sheets.

Report of 1906-1908. A report of 375 pages. Contains an index map of the State, showing the location of completed topographic surveys and of geological folios. A map showing the location of the various triangulation stations in the State and the quadrangles with primary traverse control. A map showing the lines of the precise level net within the State. A list of the triangulation stations and positions determined by primary traverse during the time covered by the report, and a list of completed topographic maps. The major portion of the volume is a geological report, giving a short account of the methods used by the United States Geological Survey within the State and the results of the co-operative geological work within the State, with 21 plates and 21 figures, by Dr. Geo. H. Ashley and others.

Report of 1908-1910. Bringing the data obtained by primary control, both horizontal and vertical, up to the first of June, 1910. A list of completed topographic maps and of the publications both of this Survey and of the United State Geological Survey relating to Pennsylvania. "A Preliminary List of the Fauna of the Allegheny and Conemaugh Series in Western Pennsylvania," by Dr. P. E. Raymond. A paper on "The Present Status of the Natural Gas Development in Pennsylvania Fields," by Mr. Frederick G. Clapp.

ECONOMIC REPORTS.

Report Number 1.

The Oil and Natural Gas Resources of the Sewickley Quadrangle, by M. J. Munn.

A detailed report on this subject in this quadrangle. This quadrangle has almost a hundred distinct oil and gas fields and pools, and the relation of structure to the various deposits forms a most interesting chapter on this subject. Perhaps the best worked out structure of any oil and gas field in this country.

Report Number 3.

The Oil and Natural Gas Resources of the Clarion Quadrangle, by M. J. Munn. A report on the oil and gas development in this quadrangle similar to that of the Sewickley quadrangle above mentioned.

Report Number 4.

The Paint Ores of Pennsylvania, by Dr. Benj. L. Miller. A detailed report of the various ores of the State used in paint manufacture and of the industry dependent thereon.

Report Number 5.

The Talc and Serpentines of Eastern Pennsylvania, by Dr. Frederick B. Peck. A short account of these deposits, bringing the present information up-to-date. More than a preliminary report.

The Cement Industry of Lehigh and Northampton Counties, by Dr. Frederick B. Peck. An account of the materials and the industry in this great cement region. This is much more than a preliminary report.

IN PRESS.

Report Number 6.

The Graphite Ores of Southeastern Pennsylvania, by Dr. Benj. L. Miller. A short report on this most interesting subject. The demand for information along this line makes this report most timely.

IN PREPARATION.

Report of 1910-1912. A short account of the work of the Survey during the two years covered by the report. A list of the completed Topographic maps. An Index Map and descriptive list of the publications of the Second Geological Survey of Pennsylvania. A list of the publications of the present Survey and a list of the publica-

tions of the United States Geological Survey relating to Pennsylvania Geology (mainly the result of work done in co-operation with the State organization). A preliminary report on the limestones of the York Valley Belt by M. L. Jandorf. A description of the little known Peridotite dike found in Fayette and Greene counties, by Lloyd B. Smith. A paper on the Geological Origin of the Fresh Water Fauna of Pennsylvania by Dr. A. E. Ortmann. A short compilation of the statistics of the mineral production of the State.

Results of the Topographic Work in Pennsylvania. A volume bringing together the data relating to the primary control work within the State, of interest to engineers. Map showing the location of the several Triangulation Stations within the State and the lines of primary traverse. A list of the Triangulation Stations and the available data concerning the same. A map showing the Primary and Precise level lines within the State and a list of the bench marks and other points whose elevation has been determined. A map showing the names adopted for each of the Quadrangles within the State and those designated where the topographic maps have been issued. A list and description of the Meridians established and other magnetic determinations in the State.

The Slate Industry in the Slatington District, by Mr. A. P. Berlin. A report covering the slate industry in all its phases in that portion of the slate belt lying near Slatington. This is not only a region of very great geological interest and of complicated structure, but one of large economic importance. The slate industry in Pennsylvania is a large one and the necessity of detailed study of the structure and of the economic features of the production of slate is pressing. It is the intention to follow this report with a study of the other producing areas in the Slate Region so that the relations of the different parts may be made clear and the geology of the whole area brought into harmony with adjoining sections.

The Broad Top Coal Field. Work has been in progress for some time in the collection of data referring to this unique coal section. It is expected that field work on the same will be completed during the coming year and a detailed report covering the whole area prepared.

A Progress Map of Southwestern Pennsylvania. A map covering 25 quadrangles, showing the outcrop of the Lower Kittanning and Lower Freeport coals, with the area of the Pittsburg coal shaded. The location and extent of the various oil and gas fields and pools and their relation to the structure, which is shown by contours on the horizon of the Pittsburg coal over an area of about 6,000 square miles.

The Clay Industry of Western Pennsylvania. Considerable work has been done toward the compilation of data for a report on the Clay industry of the western part of the State. This is intended

to cover that portion of the State where the fire clays are found, being thus largely a report on the Fire Clay Industry, but will include other ceramic products within the area treated. Work will be continued in this line with the intention of preparing a report which will be of value, not only to the producers of clays, but to the manufacturers and to the consumers of clay products as well.

The Mineral Production of Pennsylvania in 1911. The data for reports on the Mineral Production for 1911 is being rapidly collected and compiled. As soon as the data is all in and properly tabulated, reports will be completed on the several minerals produced in the State and issued as rapidly as possilble. Some of these are now well advanced.

PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

The results of the geological work done in co-operation with the United States Geological Survey, except as noted above, are published by the National Survey only.

The following is a list of the publications relating to Pennsylvania geology and all requests for the same should be made to The Director, United States Geological Survey, Washington, D. C.

Folios.

Masontown-Uniontown folio, Pennsylvania, description by M. R. Campbell. Geologic Atlas U. S., folio 82, 1902.

Gaines folio, Pennsylvania-New York, description by M. L. Fuller, Geologic Atlas U. S., folio 92, 1903.

Elkland-Tioga folio, Pennsylvania-New York, description by M. L. Fuller and W. C. Alden. Geologic Atlas U. S., folio 93, 1903.

Brownsville-Connellsville folio, Pennsylvania, description by M. R. Campbell. Geologic Atlas U. S., folio 94, 1903.

Indiana folio, Pennsylvania, description by G. B. Richardson. Geologic Atlas U. S., folio 102, 1904.

Latrobe folio, Pennsylvania, description by M. R. Campbell. Geologic Atlas U. S., folio, 110, 1904.

Kittanning folio, Pennsylvania, description by Charles Butts. Geologic Atlas U. S., folio 115, 1904.

Waynesburg folio, Pennsylvania, description by R. W. Stone. Geologic Atlas U. S., folio 121, 1905.

Elders Ridge folio, Pennsylvania, description by R. W. Stone. Geologic Atlas U. S., folio 123, 1905.

Rural Valley folio, Pennsylvania, description by Charles Butts. Geologic Atlas U. S., folio 125, 1905.

Ebensburg folio, Pennsylvania, description by Charles Butts. Geologic Atlas U. S., folio 133, 1905.

Beaver folio, Pennsylvania, description by L. H. Woolsey. Geologic Atlas U. S., folio 134, 1905.

Amity folio, Pennsylvania, description by F. G. Clapp. Geologic Atlas U. S., folio 144, 1907.

Rogersville folio, Pennsylvania, description by F. G. Clapp. Geologic Atlas U. S., folio 146, 1907.

Accident-Grantsville folio, Pennsylvania-Maryland-West Virginia, description by G. C. Martin. Geologic Atlas U. S., folio 160, 1909.

Philadelphia folio, Pennsylvania-NewJersey-Delaware, description by F. Bascom, W. B. Clark, N. H. Darton, H. B. Kümmel, R. D. Salisbury, B. L. Miller and G. N. Knapp. Geologic Atlas U. S., folio 162, 1909. Covers Norristown, Philadelphia, Chester and Germantown quadrangles.

Mercersburg-Chambersburg folio, Pennsylvania, description by George W. Stose. Geologic Atlas U. S., folio 170, 1909.

Warren folio, Pennsylvania-New York, description by Charles Butts. Geologic Atlas U. S., folio 172, 1910.

Johnstown folio, Pennsylvania, description by W. C. Phalen. Geologic Atlas U. S., folio 174, 1910.

Sewickley folio, Pennsylvania, description by M. J. Munn. Geologic Atlas U. S., folio 176, 1911.

Burgettstown-Carnegie folio, Pennsylvania, description by E. W. Shaw and M. J. Munn. Geologic Atlas U. S., folio 177, 1911.

Foxburg-Clarion folio, Pennsylvania, description by E. W. Shaw, E. F. Lines and M. J. Munn. Geologic Atlas U. S., folio 178, 1911.

Pawpaw-Hancock folio, West Virginia-Maryland-Pennsylvania, description by G. W. Stose and C. K. Swartz. Geologic Atlas U. S., folio 179, 1911.

Claysville folio, Pennsylvania, description by M. J. Munn. Geologic Atlas U. S. folio 180, 1911.

Bulletins.

Stratigraphy of the bituminous coal fields in Pennsylvania, Ohio and West Virginia, by I. C. White. Bull. No. 65, 1891, pp. 212.

Limestones of southwestern Pennsylvania, F. G. Clapp. Bull. 249, 1905, pp. 52.

Mineral resources of the Elders Ridge quadrangle, Pennsylvania, by R. W. Stone. Bull. No. 256, 1905. pp. 86.

Economic geology of the Kittanning and Rural Valley quadrangles, Pennsylvania, by Charles Butts. Bull. No. 279, 1906. pp. 198.

Economic geology of the Beaver quadrangle, Pennsylvania, by L. H. Woolsey. Bull. No. 286, 1906. pp. 132.

Economic geology of the Amity quadrangle, Pennsylvania, by F. G. Clapp. Bull. No. 300, 1907. pp. 145.

Oil and gas fields of Green County, Pennsylvania, R. W. Stone and F. G. Clapp. Bull. No. 304, 1907. pp. 110.

Geology of the oil and gas fields in Steubenville, Burgettstown and Claysville quadrangles, Ohio, West Virginia and Pennsylvania, W. T. Griswold and M. J. Munn. Bull. 318, 1907. pp. 196.

Mineral resources of Johnstown, Pennsylvania and vicinity, by W. C. Phalen and Lawrence Martin. Bull. No. 447, 1911. 142 pp. 7 pls.

Coal, oil and gas of the Foxburg quadrangle, Pennsylvania, by E. W. Shaw and M. J. Munn. Bull. No. 454, 1911. 85 pp., 10 pls.

Oil and gas fields of the Carnegie quadrangle, Pennsylvania, by M. J. Munn. Bull. No. 456, 1911. 99 pp., 5 pls.

Magnetite deposits of the Cornwall type in Pennsylvania, by A. C. Spencer. Bull. No. 359, 1908. 102 pp., 2 pls.

Copper deposits of the Appalachian States by W. H. Weed. Bul. No. 455, 1911. 166 pp., 6 pls.

On the fossil faunas of the Upper Devonian, by H. S. Williams. Bull. No. 3, 1884. 36 pp.

The Cambrian rocks of Pennsylvania, by C. D. Walcott. Bull. No. 134, 1896. 43 pp., 15 pls.

The Devonian system of eastern Pennsylvania and New York, by C. S. Prosser. Bull. No. 120, 1894. 81 pp., 2 pls.

The ancient volcanic rocks of South Mountain, Pennsylvania, by F. Bascom. Bull. No. 136, 1896. 124 pp., 28 pls.

The Glacial boundary in western Pennsylvania, Ohio, Kentucky, Indiana and Illinois, by G. F. Wright. Bull. No. 58, 1890. 112 pp., 8 pls.

Results of spirit leveling in Pennsylvania for the years 1899 to 1905, inclusive, by S. S. Gannett and D. H. Baldwin. Bull. No. 288, 1906. 62 pp.

Notes on Explosive mine gases and dusts, with special reference to explosions in the Monongah, Darr and Naomi mines, by R. T. Chamberlin. Bull. No. 383, 1909. 67 pp.

The State geological Surveys of the United States, compiled under the direction of C. W. Hayes. Bull. No. 465, 1911. 177 pp.

Economic Papers.

Anthracite coal mining, by H. M. Chance. Mineral resources U. S. for 1883 and 1884, 1885, pp. 104-131.

The Stratigraphic succession of the Fossil Floras of the Pottsville

formation in the southern Anthracite coal field, Pennsylvania, by David White. Twentieth Ann. Rept., Pt. II, 1900. pp. 749-930.

(An account of the occurrence of the Lykens coals in Stony Mountain and in the Dauphin basin.)

The Pennsylvania Anthracite Coal Field, by H. H. Stoeck. Twenty-second Ann. Rept., Pt. III, 1902. pp. 55-117.

The Bituminous Coal Fields of Pennsylvania, by David White and M. R. Campbell. Twenty-second Ann. Rept., Pt. III, 1902. pp. 127-200.

Recent work in the Bituminous Coal Fields of Pennsylvania, by M. R. Campbell. Bull. No. 213.

The Barnesboro-Patton Coal Field of Central Pennsylvania, by J. S. Burrows. Bull. No. 225.

The Elders-Ridge Coal Field, Pennsylvania, by R. W. Stone. Bull. No. 225.

Coal mining along the southeastern margin of the Wilmore basin, Cambria county, Pennsylvania, by Charles Butts. Bull. No. 225.

Pittsburg coal in the Burgettstown quadrangle, Pennsylvania, by W. T. Griswold. Bull. No. 260.

Clearfield Coal Field, Pennsylvania, by G. H. Ashley. Bull. No. 285.

The Punxsutawney and Glen Campbell Coal Fields of Indiana and Jefferson Counties, Pennsylvania, by F. B. Peck and G. H. Ashley. Bull. No. 285.

Coals of Clarion quadrangle, Clarion county, E. F. Lines. Bull. 316.

Coal resources of Johnstown and vicinity, W. C. Phalen. Bull. 316.

Brownstones of Pennsylvania, T. C. Hopkins. Eighteenth Annual Rept., Pt. V, 1897.

Cement-rock deposits of the Lehigh district, E. C. Eckel. Bull. 225.

Cement resources of Pennsylvania, by E. C. Eckel. Bull. No. 243.

Ganister in Blair county, by Charles Butts. Bull. No. 406.

Ganister in Blair county, by Charles Butts. Bull. No. 380.

Slate Deposits and Slate Industry of the United States, T. N. Dale. Bull. 275.

The slate industry of Slatington, Pennsylvania and Martinsburg, West Virginia, T. N. Dale. Bull. 213.

White clays of South Mountain, G. W. Stone. Bull. 315.

Clays and Shales of the Clarion quadrangle, Clarion county, E. F. Lines. Bull. 315.

Clays and shales of southwestern Cambria county, W. C. Phalen and Lawrence Martin. Bull. 315.

Notes on clays and shales in central Pennsylvania, G. H. Ashley. Bull. 285.

Clays of the Ohio Valley in Pennsylvania, L. H. Woolsey. Bull. 225.

Clays of the United States east of the Mississippi river, by H. Ries. Prof. Paper No. 11.

Gravel and Sand in the Pittsburg district, Pennsylvania, by E. W. Shaw. Bull No. 430.

Feldspar deposits of the United States, by E. S. Bastin. Bull. No. 420.

Barite in southern Pennsylvania, by G. W. Stose. Bull. No. 225.

Magnetite deposits of the Cornwall type in Berks and Lebanon counties, A. C. Spencer. Bull. 315.

Magnetite deposits of the Cornwall type in Pennsylvania, by A. C. Spencer. Bull. 359.

The Jauss iron mine, Dillsburg, Pennsylvania, by A. C. Spencer. Bull. No. 430.

Deposits of Brown iron ore near Dillsburg, York county, Pennsylvania, by E. C. Harder. Bull. No. 430.

Mineral paint ores of Lehigh Gap, E. C. Eckel. Bull. 315.

Ocher deposits of eastern Pennsylvania, by J. C. Stoddard and A. C. Callen. Bull. No. 430.

Paint ores near Lehigh Gap, Pennsylvania, by F. T. Agthe and J. L. Dynan. Bull. No. 430.

Paint shales of Pennsylvania, by B. L. Miller. Bull. No. 470.

Phosphorus ore at Mount Holly Springs, G. W. Stose. Bull. 315.

A Phosphate prospect in Pennsylvania, M. C. Ihlseng. Seventeenth Annual, Pt. III, 1896.

The Ninevah and Gordon oil sands in western Greene county, Pennsylvania, F. G. Clapp. Bull. 285.

The Gaines oil field in northern Pennsylvania, M. L. Fuller. Twenty-second Annual Rept., Pt. III, 1902. pp. 54.

The Hyner gas pool, Clinton county, by M. L. Fuller. Bull. 225.

Oil and gas fields of eastern Greene county, Pennsylvania, R. W. Stone. Bull. 225.

The copper deposits of South Mountain, in southern Pennsylvania, by G. W. Stose. Bull. No. 430.

Copper deposits of the Appalachian States, by W. H. Ward. Bull. No. 455.

Denudation and erosion in the southern Appalachian region and the Monongahela basin, by L. C. Glenn. Prof. Paper No. 72.

Technological.

Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1894, E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. Bull. No. 261.

Survey Work on Coal during 1905, by M. R. Campbell. Bull. No. 285. Gives a short account of geologic work on coal areas in 1905,

of the work of the fuel-testing division, and of the classification of coals.

Preliminary Report on the Operations of the Fuel-Testing Plant of the United States Geological Survey at St. Louis, Missouri, 1905. J. A. Holmes, in charge. Bull. No. 290.

Report on the Operations of the Coal-Testing Plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Missouri, 1904. E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. Prof. Paper No. 48, 1906. (In three parts.) pp. 1, 492.

Water Resources.

Water Resources of the Philadelphia district, by F. Bascom, 1904. W. S. No. 196.

Quality of water in the Susquehanna River drainage basin, by M. O. Leighton, with an introductory chapter on physiographic features, by G. B. Hollister, 1904. W. S. No. 108.

Hydrography of the Susquehanna River drainage basin, by J. C. Hoyt and R. H. Anderson, 1905. W. S. No. 109.

Papers on the Water Resources of Chambersburg, Mercersburg, Curwensville, Ebensburg, Barnesboro, Elders Ridge, Waynesburg, Accident and Grantsville quadrangles, by M. L. Fuller, Geologist in charge, 1904. W. S. No. 110.

The Potomac River basin, by Bailey Willis, R. H. Bolster, H. N. Barker, W. W. Ashe and M. C. Maesh, 1907. W. S. No. 192, pp. 364.

Underground waters of eastern United States, by M. L. Fuller. W. S. No. 114.

Papers on stream measurement have been published under different titles in Water-Supply and Irrigation Papers as follows: Nos. 47, 48 (1901), 82 (1903), 97 (1904), 125, 126, 128 (1905), 167, 169 (1906), 202, 203, 205 (1907), 206 (1907), 241 (1909), 243 (1910), 261, 263, 281, 283 (1911).

APPENDIX C

LIST OF COMPLETED TOPOGRAPHIC MAPS.

The annexed table represents the completed maps, which are published, and can be had from the United States Geological Survey. Others are in course of publication and will soon be issued.

Quadrangle.	Area mapped.
Accident (Md.-Pa.,-W. Va.),	25.86
Allentown,	226.73
Amity,	228.40
Andover (Pa.-Ohio),	17.60
Barnesboro,	226.73
Beaver,	226.73
Bedford,	228.40
Blair (Pa.-W. Va.),	26.00
Bellefonte,	225.90
Blacksville (W. Va.-Pa.),	26.28
Bloomsburg,	225.06
Bordentown (N. J.-Pa.),	2.82
Boyertown,	227.57
Brownsville,	228.40
Bruceton (W. Va.-Pa),	26.61
Burgettstown,	227.57
Burlington (Pa.-N. J.),	138.50
Butler,	225.90
Camden (N. J.-Pa.-Del),a	209.73
Cameron (W. Va.-Ohio-Pa.),	17.60
Carlisle,	228.40
Carnegie,	227.57
Catawissa,	225.90
Chambersburg,	229.22
Chester (Pa.-Del.-N. J.),b	153.73
Clarion,	225.06

a. Chester and Philadelphia sheets, on scale of 1:62,500, have been reduced, and form parts of Camden sheet, on scale of 1:125,000.

b. Philadelphia and vicinity sheet includes Chester, Germantown, Norristown and Philadelphia sheets.

Quadrangle.	Area mapped.
Claysville,	228.40
Coatesville,	229.22
Columbiana (Pa.-Ohio),	17.60
Conneaut (Pa.-Ohio),	16.00
Connellsville,	228.40
Curwensville,	225.90
Delaware Water Gap (Pa.-N. J.),	131.01
Doylestown (Pa.-N. J.),	207.10
Dundaff,	223.36
Easton (Pa.-N. J.),	80.18
Ebensburg,	227.57
Elders Ridge,	226.73
Elkland,	222.50
Elkton (Md.-Del.-Pa.),	28.50
Elmira (N. Y.-Pa.),	1.55
Emmitsburg (Md.-Pa.),	26.00
Erie,	114.61
Everett,	228.40
Fairfield,	229.22
Fairview,	22.92
Flintstone (Md.-Pa.-W. Va.),	26.91
Foxburg,	225.06
Franklin,	224.21
Freeport,	226.73
Frostburg (Md.-W. Va.-Pa.),	26.37
Gaines,	222.50
Germantown (Pa.-N. J.),c	225.00
Gettysburg,	229.22
Girard,	219.50
Grantsville (Md.-Pa.),	25.86
Greensburg,	227.57
Hamburg,	226.73
Hancock (W. Va.-Md.-Pa.),	25.37
Harrisburg,	227.57
Harvey Lake,	224.21
Havre de Grace (Md.-Pa.),	25.36
Hazleton,	225.90
Hilliards,	225.06
Hollidaysburg,	227.57
Honesdale,	226.36
Honeybrook (Suplee),	228.40

c. Philadelphia and vicinity sheet includes Chester, Germantown, Norristown and Philadelphia sheets.

Quadrangle.	Area mapped.
Houtzdale,	225.90
Hummelstown,	227.57
Huntingdon,	227.57
Indiana,	226.73
Johnstown,	227.57
Kinsman (Pa.-Ohio),	17.60
Kittanning,	225.90
Lambertville (Pa.-N. J.),	49.86
Lancaster,	228.40
Latrobe,	227.57
Lebanon,	227.57
Linesville,	223.36
Littleton (W. Va.-Pa.),	1.95
Lykens,	226.73
McCalls Ferry,	229.22
Mahanoy,	225.90
Mannington (W. Va.-Pa.),	26.28
Masontown,	229.22
Mercersburg,	229.22
Middletown,	228.40
Millersburg,	226.73
Millerstown,	226.73
Morgantown (W. Va.-Pa.),	26.90
New Bloomfield,	227.57
New Castle,	225.90
Neshannock,	225.06
New Cumberland,	228.40
New Holland,	228.40
New Kensington,	226.73
Norristown,d	228.40
Owego (N. Y.-Pa.),	1.29
Parkton (Md.-Pa.),	26.00
Patton,	226.73
Pawpaw (Md.-W. Va.-Pa.),	25.86
Philadelphia (Pa.-N. J.),e	56.00
Philadelphia and vicinity (Pa.-N. J.-Del.),f	623.13
Phoenixville,	228.40
Pinegrove,	226.73
Pittsburg,	227.57
Pittston,	224.21

d. Philadelphia and vicinity sheet includes Chester, Germantown, Norristown and Philadelphia sheet.

e. Chester and Philadelphia sheets on scale of 1:62,500, have been reduced, and form parts of Camden sheet, on scale of 1 ,125,000.

f. Philadelphia and vicinity sheet includes Chester, Norristown and Philadelphia sheets.

Quadrangle.	Area mapped.
Port Jervis (N. J.-Pa.),	6.00
Pottsville,	226.73
Punxsutawney,	225.90
Quakertown,	227.57
Quarryville,	229.22
Reading,	227.57
Rogersville,	229.22
Rural Valley,	225.90
Scranton,	224.21
Sewickley,	226.73
Shamokin,	225.90
Shenango,	224.21
Shickshinny,	225.06
Slatington,	226.73
Smicksburg,	225.90
Steubenville (Ohio-W. Va.-Pa.),	17.60
Sunbury,	225.90
Taneytown (Md.-Pa.),	26.00
Tioga,	225.50
Uniontown,	229.22
Wallpack (N. J.-Pa.),	52.50
Warren (Pa.-N. Y.),	219.00
Waynesburg,	229.22
Wellsville (Ohio-W. Va.-Pa.),	17.60
Wernersville,	227.57
West Chester (Pa.-Del.),	165.55
Westminster (Md.-Pa.),	26.00
Wheeling (W. Va.-Ohio-Pa.),	17.60
Wilkes-Barre,	225.06
York,	229.22
York special,	75.33
Youngstown (Ohio-Pa.),	17.60
Zelienople,	225.90
Total area (139 quadrangles) published,	23,322.19

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Belt, together with a description of the Limestone and minerals occurring therein. Included, also, are chemical, physical and petrographical tests made on certain limestones, limes, hydrates and "traps."

Description and Nomenclature.

Th

In the classification by Rogers these limestones were termed the "Auroral" limestones, to distinguish them from those formed at a later period.

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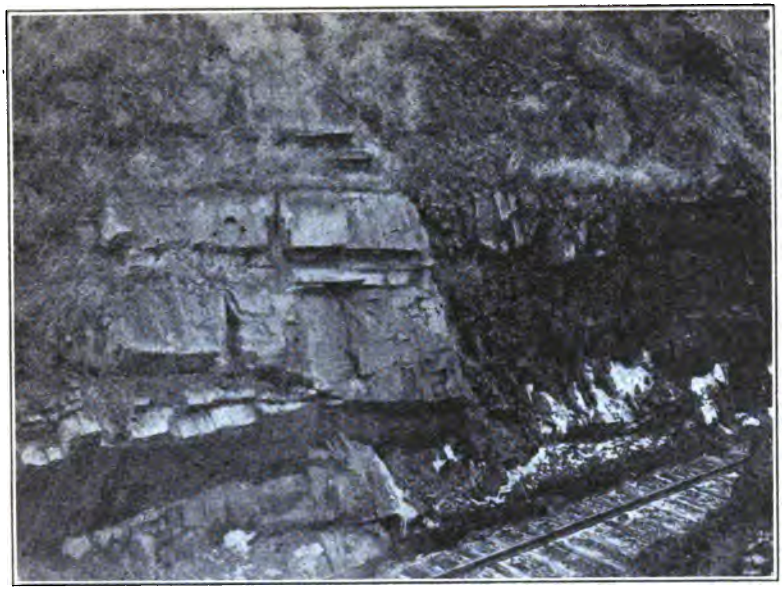

A.

Plate VII. Looking N. along the P. R. R. "York Branch" tracks. Stony Brook.

B.

Stony Brook dike, in contact with the York Valley Limestone Belt. Looking S. along the P. R. R. "York Branch" tracks.

A.

Plate VIII. "Trap" boulders in place. Intersection of the Board Road and King's mill road.

B.

Contact between limestone and a dike 300 feet west of the West York dike. Along the W. M. R. R., near Bricklyn. (Lower left-hand corner—limestone; center and right of picture—trap.)

between "hydro-mica schists" and limestone, occurs. From this point, the boundary continues almost parallel with "Lightner's run" and in a comparatively wide belt, at the base of the "schists" and in the lowland or valley, through which the Harrisburg-Baltimore turnpike passes. At many points in the neighborhood of "Lightner's run" are numerous beds of shale (possibly "hydro-mica schists") conformably overlying the limestone.

Continuing northeastward for about a mile, the limestone swings around in the valley towards Myer's mill, along Codorus creek and thence, in the lowland, along the south side of Codorus creek and across the stream in the field at some distance from the base of the "Pleasureville Hills." (Ref. 4, pp. 89-90; Ref. 7, pp. 11-19) until it again laps against the "hydro-mica schists" about one mile east of Rudy's mill, when it swings to the northwest towards Emigsville and continues westward at the base of the "hydro-mica schists" until the northern end of Emigsville is reached, where a contact between Triassic sandstone and shale and Cambrian "hydro-mica schists" and limestone occurs.

Continuing a little southwest of Emigsville, the body laps against the Triassic sandstone and shale, until a point is reached a few hundred feet south of the intersection of the "Board Road" and a road leading to King's mill, along the Little Conewago creek. Here a sharp contact occurs between the limestone and the Triassic sandstone, conglomerate and shale.

At the intersection of the "Board Road" and King's mill road a "trap" (Plate VIII) dike cuts through the Triassic sandstone, and, a little further southwest, through the limestone (Cambrian). The direction of this dike is slightly northeast-southwest. No contact minerals have been observed here. The microscopical character of this dike-rock is similar to that of the Stony brook dike, except that the constituents are coarser grained. This dike is the northeastern extremity of the one cutting the limestone at a point about 2½ miles west of York.

From here the limestones are unconformably overlain on the North by Triassic sediments, until a point is reached 2½ miles northwest of Thomasville, where a contact between Triassic sandstone, shale and conglomerate and Cambrian quartzite (Potsdam sandstone), occurs. The York Valley limestones, at this point, form an embayment to the northwest of the eastern extremity of the Pigeon Hills. Continuing westward along the southern base of this range, to the Adams county line (2½ miles northwest of Hanover), the limestones are conformably overlain by Cambrian quartizite or Potsdam sandstone, which constitutes the entire range of hills known as the Pigeon Hills.

Southern Boundary.

From a point a few hundred feet south of the mouth of Creitz creek and continuing westward to a point about 4½ miles southwest of York, the limestones are faulted against the Azoic slates of Rogers. From this point, the Codorus creek marks the boundary for 5½ miles. One-half mile west of Spring Grove, the limestones again lap against the Azoic slates, westward to the Adams county line, one mile west of Hanover, Pennsylvania.

A series of trap dikes cut the limestone belt at a point one-half mile west of Hanover and continue southward to the southern boundary of the limestone. This set of dikes is approximately three miles in length and strikes north and south. In all respects, they are similar to the Stony Brook and West York dikes.

Generally speaking, the southern boundary of the York Valley Limestone Belt continues in a comparatively straight line, from east to west, whereas the northern boundary presents numerous extensive embayments. The narrowest part of the entire belt lies about 3½ miles west of Spring Grove, where it is but three-eighths of a mile in width. From here, however, the northern boundary winds around the Pigeon Hills until in the neighborhood of Hanover, where the width of the belt approximates six miles.

West of York, between York and Thomasville, numerious dikes of diabase were observed, which have heretofore not been recorded. Along the contact of one of these dikes with the limestones under discussion, a deposit of high grade iron ore has been discovered.

West of York, the general dip of the limestones is to the south, although this is by no means always the case. The limestones are abundantly overlain by shales and these appear in many instances, to be shaly limestones. Whereas east of York to the Susquehanna river the shaly limestones persist, west of York to the Adams county line the most predominant type is a gray, compact, fine grained dolomitic limestone, together with a subordinate amount of light-blue, shaly, pyritiferous limestone.

Near Bricklyn, along the Western Maryland Railroad, a contact between the above-mentioned shale and gray, dolomitic limestone (see Plate IX), is noticed and this is a common occurrence at many other points throughout the "belt." Between Smyser's Station, on the York and Hanover trolley line and the plant of the L. M. Palmer Lime Company, there is a knob consisting of beds of a green chloritic slate and a gray shale, both of which dip to the southeast. This knob continues westward forming a ridge and while it overlies the limestones, it likewise in part separates the limestone body, west of York, into two arms or offshoots.

Plate IX. Contact between limestone and shale. 3½ miles W. of York, Pa., near Bricklyn Station, on the W. M. R. R.

Structural Geology of the York Limestone Belt.

This belt, with its associated over-and under-lying formations, has been described by previous geologists. The writer makes no attempt to discuss the geology in detail. A list of references is given which will enable any one to obtain very complete information relating to the geology.

Beginning at a point just north of Wrightsville, and along the Susquehanna river, continuing westward along its northern boundary, the York Valley Limestone Belt is conformably overlain by Cambrian sediments, composed of Potsdam sandstone (Hellam or Chickies quartzite) with irregular intercalated beds of "hydro-mica" schists until a point is reached in the cut of the Northern Central Railway, just north of Emigsville. From here, to the eastern base of the Pigeon Hills, the limestone is unconformably overlain by Mesozoic (Triassic) sediments, mainly sandstone, shales and quartzose conglomerate. Near the mouth of the Creitz creek and continuing westward along the southern boundary, the limestones are unconformably overlain by the Azoic slates of Rogers, until a point is reached about 4½ miles southwest of York. From there the Codorus creek marks the boundary for 5½ miles, when the Azoic slates again appear and continue westward to Adams county.

Local metomorphism has affected many parts of the belt, resulting in folding and fracturing of the beds often with decided changes in the dip and strike. Metamorphic minerals are of frequent occurrence.

According to Walcott (Ref. 1), and Frazer (Ref. 8, p. 4) this body, which the latter termed the "York" limestone, is a slender offshoot of the Lancaster limestone, these two types having been considered equivalent to the Calciferous and Trenton limestones of the New York series (Ref. 4, p. 40). The Hellam quartzite forms a broad anticlinal fold, surrounded by "hydro-mica" schists. The dip is south and under the slates ("hydro-mica schists"), the dip of the slates being similarly south and under the limestones, forming the "York Valley." A section along the southern and western borders of the Hellam hills shows that the quartzite passes beneath a series of shales (Ref. 1, pp. 475-6), slates, and sandy and calcareous layers, that in turn pass under the valley limestones. Southeast of the Hellam hills, according to Walcott, the limestones form a compressed syncline. Frazer (Ref. 4, p. 130) says that there is much unconformity between the "York" (Ref. 2, pp. 220-223) limestone and "crystalline" schists and summarily classifies the rocks bearing upon these limestones as:

4. Limestone (Siluro-Cambrian.)
3. Hydro-mica schists.
2. Quartzite (Potsdam sandstone).
1. Chlorite schists.

From the fact that in Tennessee, Vermont and New Jersey, the lower portion of the great limestone series above the quartzite and shales, is undoubtly of Cambrian age (Ref. 7, pp 11-12), Walcott thinks (Ref. 9, pp. 36-41) a sharp line should be drawn between Cambrian limestone and Ordovician limestone (Ref. 7, pp. 191-8), in the various counties in Pennsylvania through which the belt passes. This he concludes from the discovery of certain fossils found in these limestones, which are undoubtedly of Cambrian age. He also contends that (Ref. 1, p. 475) the fossils observed tend to classify the sandstones, limestones and schists (presumably "hydro-mica") as belonging to the Cambrian age and that the Potsdam horizon of the New York series is represented by limestone in the "Auroral" series of Rogers (Ref. 2, pp. 220-3.)

To correlate the different beds in this region will require careful and patient detailed study, owing to the complexity of the structure. The region is so highly faulted and folded and there is so much covering of soil, that it is difficult to form any definite opinion regarding the structure. In general, however, it may be stated that from paleontological evidence gathered throughout the region, the limestones are characteristic of the lower and middle Cambrian horizons. Numerous fossils, characteristic of the lower and middle Cambrian, have been found at or near the contact of the limestones with the schistose slates. The following list of localities (Walcott, Ref. 10, pp. 573-575), with the fossils observed, will aid in determining the features of the various beds in this district.

Locality No. 1—Quarry in a field east of the N. C. R. R. tracks and near where the road turns east towards the Codorus Creek. Strike N. 15° W. (mag). Dip 15° S.

Locality No. 2—Quarry east of the N. C. R. R. tracks.

Locality No. 3—Quarry along the N. C. R. R. Strike E. and W. (mag). Dip 10° S. (At present filled with water.)

Locality No. 4—4 miles N. of York, on the left hand band of Codorus Creek, one-eighth mile below Myre's Mill, near Emigsville.

Locality No. 5—3 miles N. W. of York; S. of Emigsville and Eisenhardt's schoolhouse, on the Liverpool road (present board road).

Locality No. 6—One and one-eighth miles N. of Stoner's station (along Wrightsville-Hanover Short Line).

Locality No. 7—Cutcamp's (Kottcamp's; now abandoned) quarry N. of Cottage Hill, York.

Locality No. 8—Roadside N. of Highland Park, York.

Locality No. 9—Cellar diggings. Penn and North Streets, York.

Locality No. 10—N. of locality Number 1 (about 600′).

Locality No. 11—2 miles N. W. of Locality Number 10.

Fossils Determined.

Locality No. 1—*Iphidea bella,* Billings; undet. sp; *Salterella conica; Protypus senectus,* Billings; *Solenopleura* and *Zenanthoides* (both trilobites), head of each; *Olenellus,* undet. sp., fragments of head and thorax.

Locality No. 2—Fragments of *Protypus senectus,* Billings; an undet. sp. of *Olenellus.*

Locality No. 3—*Protypus senectus,* Billings; immense fragments of an undet. sp. of *Olenellus; Cystid* plates; undet. sp. of *Kutorfina; Billingsella festinata,* Billings.

Locality No. 4—*Protypus senectus,* Billings; undet. sp. of *Ecystites;* two undet. sp. *Brachiopoda.* Specimens collected by Prof. A. Wanner and Mr. Chas. Schuchert.

Note: The two undetermined Brachiopoda, found at the above locality have since been named and belong to the genera *Yorkia* (Ref. 11, p. 715), and *Nisusia.* (Ref. 12, pp. 249-251). The species are *Yorkia, wanneri,* Walcott, and *Nisusia festinata.* Billings, (originally *Billinesella festinata,* Billings

Locality No. 5—New sp. *Salterella conica; Billingsella festinata,* Billings; *Hyolithes americanus,* Billings; *Olenellus thompsoni,* Hall.

Note: Two new species (found by Prof. A. Wanner) of *Olenellus* viz *Olenellus* (Holmio) *Walcottanus,* Wanner (Ref 13, pp. 267-272) and *Paedeumias transitans,* Walcott (Ref. 14, pp. 231-422), occur near locality No. 5, in an argillaceous shale near the contact between the Cambrian and Triassic.

Locality No. 6—Numerous fragments of *Olenellus,* undet. sp. abundant; *Linnarssonia sagittalis.*

Note: The species *Acrothele decipiens,* (Ref. 11 p. 716), a lower Cambrian brachiopod, also occurs here.

Locality No. 7—An undet sp. of *Zacanthoides; Cystid* plates; *Microdicus,* like *Microdiscus parkeri,* Walcott; *Ptychoparia adamsi,* Billings, and *Paychoparia teucer,* Billings; and undet. sp. of *Agraulos.*

Note: The new species *Paedeumias transitans,* Walcott, occurs here.

Locality No. 8—*Protypus senectus,* Billings; a *Ptychoparia; Olenoides* like *Olenoides marcoui,* Whitefield.

Locality No. 9—*Zacanthoides; Eocystites,* undet. sp.; an undet. sp. of *Bathyuriscus;* two undet. sp. of *Ptychoparia;* an undet. sp. of *Acrotreta;* an undet. sp. of *Agnostus.*

Locality No. 10—*Camarella minor* and fragment of *Olenellus,* in a Calcareous quartzite.

Locality No. 11—*Camarella minor; Obolella crassa* (?); *Hyolithes communis* and fragments of *Olenellus,* in a calcareous sandstone.

Addenda.

Olenellus thompsoni crassimarginatus at Locality No. 5 and two miles northeast of York, in drab and gray calcareous, arenaceous and argillaceous shale. *Olenellus thompsoni,* Hall, was found at the last mentioned locality. Also N. of the station at Emigsville; 4 miles N. E. of York and 1 mile S. of Mt. Zion Church.

Acrothele yorkensis, a new species, found in the argillaceous shale in the railroad cut, alongside the gashouse, York, Pa., and north and N. E. of York. East, on the strike of shale across York County to the Susquehanna River.

According to Messrs Walcott and Wanner, the fossil genera thus far observed in the York Valley Limestones are all of Cambrian age, but the species found characterize beds of lower and middle Cambrian. Below are two tables Number I, (Ref. 15 and Ref. 16), showing the position of the genera found in the Cambrian throughout the York Valley, and Number 2 (Ref. 7), correlating and showing the occurrence, in other localities of the "lower Cambrian" fauna, characteristic of the York Valley Limestone Belt.

Table No. I—Position in the Geological Scale of the Cambrian Fauna Observed in York Valley Limestone Belt.

Upper Cambrian, Dicellocephalus or Potsdam Horizon.	TRILOBITAE:	*ptychoparia, agraulos, agnostus, microdiscus (?).*
	BRACHIOPODA:	*billingsella, obolella, camarella, acrotreta, acrothele,*
	PTEROPODA: or GASTEROPODA:	*hyolithes.*
	ECHINODERMATA:	*eocystites (?).*
Middle Cambrian, Paradoxides or Acadian Horizon.	TRILOBITAE:	*olenoides, ptychoparia, agnostus, microdiscus, solenopleura*
	BRACHIOPODA:	*linnarssonia, acrotreta, nisusia, acrothele.*
	PTEROPODA: or GASTEROPODA:	*hyolithes.*
	ECHINODERMATA:	*eocystites.*
Lower Cambrian, Olenellus or Georgian Horizon.	TRILOBITAE:	*olenellus, microdiscus, ptychoparia, olenoides, agnostus, solenopleura, bathyuriscus, protypus, paedeumias, wanneria.*
	BRACHIOPODA:	*kutorgina, iphidea, acrotreta, billingsella, camarella, obolella, acrothele, nisusia, yorkia.*
	PTEROPODA: or GASTEROPODA:	*hyolithes, salterella.*
	ECHINODERMATA:	*eocystites.*

Table No. 2—Correlation of the Lower and Middle Cambrian Fauna of the York Valley Limestone Belt with those of other Localities.

Name.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Eocystites,	x	x										
Acrotreta (sp. undet),	x											
Acrothele yorkensis,	x											
Iphidea bella, Billings,	x		x	x								
Kutorgina (sp. undet.),	x											
Linnarssonia sagittalis, Salter,	x											
Hyolithes communis, Billings,	x		x		x	x	x					
Hyolithes americanus, Billings,	x		x			x	x	x				
Salterella conica,	x											
Agnostus (sp. undet.),	x					x						
Microdiscus parkeri, Walcott,	x											
Olenellus thompsoni, Hall,	x		x	?	x			?				
Olenellus thompsoni, crassimarginatus,	x				x							
Olenodes marcoui, Whitfield,	x		x		x							
Zacanthoides (sp. undet.),	x											
Ptychoparia adamsi, Billings,	x		x		x				x			
Ptychoparia teucer, Billings,	x		x		x							
Agraulos (sp. undet.),	x											
Protypus senectus, Billings,	x		x	x	x				x			
Solenopleura (sp. undet.),	x											
Obelella crassa, Hall,	x		x			x	x					
Camarella minor, Walcott,	x					x						
Bathyuriscus (sp. undet.),	x											
Olenellus (Holmia), or Wanneria, walcottanus, Wanner,	x								x	x		
Nisusia (Billingsella), festinata, Billings,	x		x		x	x						
Acrothele decipiens,	x											
Yorkia wanneri,	x											
Paedeumias transitans, Walcott,	x	x	x	x					x	x	x	x

Localities as follows:
1. York county, Pa.
2. Highland Range (Rocky Mts.)
3. Bic Harbor (St. Lawrence Region).
4. Labrador.
5. Western Vermont.
6. Eastern New York.
7. Eastern Massachusetts.
8. Eastern Tennessee.
9. British Columbia.
10. Central Alabama.
11. Newfoundland.
12. Silver Peak Range, Nevada.

DESCRIPTION OF A SMALL TRIANGULAR BODY OF LIMESTONE NEAR NEW HOLLAND, YORK COUNTY.

This body of limestone, which lies between parallels 40°3′48″., and 40°5′. and meridians 76°40′., and 76°4′41″., is more or less triangular in shape (Ref. 2, pp. 220-3) and lies directly northwest of New Holland (Saginaw P. O.) and along the Susquehanna River. It is the termination in York County, of the limestone body across the Susquehanna, at Bainbridge and Billmyer P. O., in Lancaster County.

It is bounded on the northwest by Triassic quartzose conglomerates and on the south by "hydro-mica schists." The southwestern apex of the triangular body terminates at the junction of the Triassic conglomerate and "Hydro-mica schists."

A sharp contact between Triassic conglomerate and dolomitic limestone (Plate X) can be seen along the road from New Holland to York Haven, between the Susquehanna River and the tracks of the "Low grade" freight line of the Pennsylvania Railroad. The southeastern boundary is observed along the river road, at a point a few hundred feet south of the Star View road (main road to the village).

Chapter II.

Economic Geology of the York Valley Limestone Belt.

Limestone.

Description: A limestone is a rock composed in the main of carbonate of lime or as it is technically termed, carbonate of calcium. Upon heating to a comparatively high temperature, the calcium carbonate splits up into calcium oxide, or lime, and carbonic gas, or carbon dioxide. Its chemical formula is $CaCO_3$, when absolutely pure, but commercially, this is not the case, owing to the impurities always present.

Origin: The origin of limestones is easily explained and easy to understand. They may be either marine or lacustrine deposits, formed by the chemical deposition of the calcium carbonate contained in the waters (which invariably carry this salt in solution, in greater or lesser quantities). The cause of deposition may be either some chemical precipitant or living organisms, such as molluscs, foraminifera or corals. These animals, especially the molluscs, are capable of secreting the calcium carbonate from marine or lacustrine waters and this secretion is the chief constituent of their shells. Naturally, when these animals die, their shells sink to the sea (or lake) bottom and by their rapid accumulation, form calcareous beds. In falling

A.

Plate X. Contact between the Cambrian limestones and Triassic conglomerate. Along the tracks of the P. R. R. Low-grade Freight Div. Near New Holland, York Co. (Limestone—right foreground; conglomerate—left of center.)

B.

Contact between Cambrian limestone and Triassic conglomerate. Along the tracks of the P. R. R. Low-grade Freight Division. Near New Holland, York County.

Plate XI. Walcott's "Intraformational Conglomerate." In Stoner's abandoned quarry, N. of Stoner's station, on the P. R. R. "York Branch."

to the bottom these shells by close and constant grinding are finally deposited as a slimy mass. The grinding tends to eliminate all traces of the original shell structure and is the reason for the scarcity of fossil remains in many bedded limestone deposits, such as the one described in this report.

The fact that calcium carbonate is very soluble in water containing free carbon dioxide, causes the formation of a soluble double compound, viz: basic calcium carbonate or calcium bicarbonate, $CaH_2C_2O_6$ which compound (only known to occur in solution) in turn, acts as a cement in binding together the finely comminuted and slimy particles of shells.

It is generally calculated that the primary crystalline rocks contained from one to fifteen per cent. of lime. These rocks have been acted upon by atmospheric gases to such an extent that the basic carbonate was formed (together with calcium nitrate and sulphate), from the calcium silicates, these new calcium salts being soluble to a greater or lesser extent, finally find their way to the ocean, being carried there by running waters.

Oolitic and pisolitic limestones, of which there are a few of the latter type in York County, owe their origin to the fact that particles of dust or grains of silica suspended in springs containing much lime, or in concentrated estuarine or bay waters collect concentric shells of calcium carbonate and then form the oolitic deposits from the coalescence of the concretions.[1]

PHYSICAL AND CHEMICAL PROPERTIES OF LIMESTONE.

Limestones vary greatly in color, texture and composition. Rarely, in York County, is any one type presistant over a wide area. They may be fine-grained and earthy, to coarse-grained; finely, to coarsely-crystalline. They vary in color, but are commonly blue, gray, white and black; some are yellow, red or brown.

At various points throughout the York Valley Limestone Belt, a typical limestone conglomerate (Ref. 17, pp. 192-8) occurs. This is especially so of many outcrops observed at points on or near the road leading from the York and Wrightsville turnpike to Stoner's station on the Pennsylvania Railroad, "York Branch." In Stoner's old quarry near the railroad station, parts of the north wall (see Plate XI) present this feature. In other parts of the belt, there are compact marbles.

The color of white and green limestones is due to the presence of iron compounds, such as carbonate and silicate of iron, respectively; in yellow, red and brown limestones, the color is due to hydrated sesquixide of iron; in black limestones, some carbonceous matter is

[1]There are many references on the origin of limestones, one of the best being Bulletin No. 491, of the U. S. Geol. Surv., entitled, "The Data of Geochemistry." (2d Ed.) by F. W. Clarke.

present; blue colored limestones owe their color chiefly to organic matter and in a great majority of cases to graphitic carbon, which, when the limestone is dissolved in acid, floats as a scum on the surface. Many dark colored limestones emit, upon being struck with a hammer, an odor of sulphuretted hydrogen.

G. P. Merrill (Ref. 18, p. 199) says that the York County limestones, in general, are very fine-grained and compact in texture and of a deep-blue color. They take a high polish and, but for their uneven texture, would undoubtedly make fine marbles. He further states that in Wrightsville, a white or bluish crystalline, granular stone is quarried, which takes a fair polish.

Generally speaking, however, the limestones in York County vary from a very pure, uniformly composite type, to a true dolomite. They may be either massive, compact, tough and thickly-bedded or soft, shaly, friable and very thinly-bedded. The thickly-bedded limestones are much higher in lime content than the thinly-bedded ones (high in magnesia and silica). In color, they range from a pure, clear white, resembling some fine marbles, to a very dark-blue, almost blacq type. Limestones possessing fetid odors were observed, the odors being due in part to phosphate of calcium, and to the decomposition of iron sulphide. In other places limestones possessing an argillaceous odor were noticed, this odor being caused by the abundance of clayey matter present as a decomposition of some silicates. The most persistent type of limestone possesses a shaly and thinly-bedded appearance.

[One may find a wide variation in the composition of limestones found in the same quarry. This was shown by McCreath (Ref. 3, pp. 311-361) in Walton's (McCormick's) quarry, opposite Harrisburg.]

An approximate mean average specific gravity for a pure limestone is 2.7, thereby making the weight of a cubic foot of pure limestone 170 pounds. A cubic foot of dolomite, with a specific gravity of 2.9, will weigh 181.25 pounds. This physical character depends in part upon the chemical composition and constituents, and in part on the compactness of the limestone. A perch of limestone, or 24.75 cubic feet, will weigh about 4,205 pounds, whereas a perch of dolomite will weigh approximately 4,450 pounds.

The crushing strength of a limestone ordinarily varies from 10,000 to 15,000 pounds per square inch, depending on the compactibility and absorptive power (in part, porosity) of the limestone. As a rule limestones are generally low in absorptive power, due to the compactness of the stone. All limestones contain "quarry water," from three-tenths to five per cent., varying with the porosity of the stone. Limestones are, as a rule, soft, and it is well to remember that hardness and compactness are distinctly different physical properties.

A.

Plate XII. S. W. wall of the L. M. Palmer Lime Company's quarry. (Thickly-bedded limestones.) About 2 miles S. W. of York, Pa.

B.

North wall of the quarry of John H. Longstreet. (Showing thinly-bedded limestone.) 2 miles E. of York, Pa.

A.

Plate XIII. West wall of the quarry of John H. Longstreet. About 2 miles E. of York, Pa. Showing shaly bedding.

B.

S. E. wall. Thomasville Stone and Lime Co., Thomasville, Pa. Showing massive white limestone.

A limestone such as chalk, while very porous and compact, is likewise very soft. On the other hand the presence of too much silica would probably cause the limestone to become harder, but not necessarily more compact, for example calcareous sandstones. Some limestones will crumble under the least compression, whereas others require a sharp blow to even cause fracturing or chipping off of fragments.

The complete calcination of a pure limestone(i. e., one very low in magnesia, requires a temperature varying between 900° C. (1.652° F.) and 1,316° C. (2.400° F.), depending upon the texture of the stone. Calcination begins at 750° C. (1,382° F.). A high magnesian lime, on the other hand, is completely calcined at a temperature between 1,000° C. and 1,038° C. (1,832° F. and 1,900° F.). An absolutely chemically pure limestone, other than the mineral calcite, is never commercially abundant, but is often closely approached. Were such a limestone possible, we would find it to be composed of 100 per cent. of calcium carbonate, or 56 per cent. of lime and 44 per cent. of carbon dioxide. This latter compound, being a gas, is usually allowed to escape, but is made use of in numerous commercial operations.

It is unusual to obtain large quantities of a very high grade limestone, most of them consisting of calcium carbonate together with some magnesium carbonate, sesquioxide of iron, iron disulphide, or the mineral pyrite, silica as quartz or various silicates of alumina, magnesia, etc., and many other minor impurities in too small quantities to affect the burning of the limestone.

Magnesia, as magnesium carbonate, when present in a limestone is erroneously termed an *impurity.* It acts in the same manner as lime, but with less rapidity. Some limestones contain magnesia in the form of dolomite, occurring therein, as spheroidal, botryoidal and irregularly outlined concretions. Silica, alumina, sulphur, iron, phosphorus, etc., are genuine impurities and in many instances are detrimental to the commercial value of the lime produced.

Typical Analyses of High Calcium Limestones.

	1.	2.	3.	4.	5.
CaO,	54.48	54.68	55.74	54.87	55.46
MgO,	0.36	0.32	0.51	0.20	0.26
CO_2,	43.40	43.44	42.76	43.34	43.86
SiO_2,	0.89	0.87	0.86	0.40	0.24
Al_2O_3,	0.38	0.34	0.29	0.44	0.38
Fe_2O_3,	0.25	0.13			
H_2O,			0.04		
Total,	99.76	99.78	100.20	99.25	100.20
$CaCO_3$,	97.484	97.768	97.939	97.99	99.034

1. Bedford Portland Cement Company, Bedford, Ind., A. W. Smith, analyst. 20th Ann. Rep. U. S. Geol. Sury. Pt. 6, p. 381.
2. Ibid.
3. Iola Portland Cement Co., Iola, Kansas, H. N. Stokes, analyst. Bull. 78, U. S. Geol. Surv., p. 124.
4. Atlas Portland Cement Co., Ilasco, Mo. E. Davidson, analyst.
5. Ibid.

There are impurities present in limestones in various forms and compounds:

Silica occurs as minute quartz grains, quartz crystals, chert nodules, flint nodules, vein quartz; as silicates of magnesia, alumina, iron, etc., and as opaline quartz (rarely in bedded limestone deposits).

Alumina occurs in silicates and in clays of various composition associated with the limestones.

Iron is present, primarly as pyrite or disulphide, which, upon exposure, alters to the anhydous sesquioxide, hematite, and eventually to the hydrated sesquioxide, limonite. Iron is also present as the carbonate, siderite, or carbonate of iron, and ankerite, or carbonate of iron, manganese, magnesium and calcium. Silicates of iron are rare in limestones, but there are many silicates of magnesium and aluminum that contain iron, but only, as a rule, in the form of hydrated oxides.

Sulphur is present as pyrite, barite, gypsum, chalcopyrite and sphalerite, but the first predominates over the others. Pyrite is the disulphide of iron; barite, barium sulphate; gypsum, hydrous calcium sulphate; chalcopyrite, iron and copper sulphide; and sphalerite, zinc sulphide. . .

Phosphorus is present as the mineral apatite or calcium phosphate (with fluorine or chorine), though rarely in York County. It is present in some limestones in quantities varying from six-tenth to ten per cent.

Fluorine occurs in the mineral fluorite, fluorspar or calcium fluoride, and is more abundant than it appears. It is usually found in the dark colored (especially blue) limestones; more rarely so, in lighter colored limestones.

Carbon occurs as the mineral graphite, usually impure and uncommon to many localities.

Some of these impurities are detrimental to the limestones before calcining. Pyrite, upon altering, is converted into brown hydrated sesquioxide of iron, which stains the stone, while the sulphur present forms sulphuric acid, this in turn, decomposing the stone, finally causes disintegration. Too much magnesia will cause the rock to disintegrate and crumble, such is the case with the dolomite limestone new New Holland, York County. Silica and alumina are usually present in such forms as are detrimental to the burning of limestone.

Chemically pure limestones are readily soluble in water containing carbon dioxide (carbonic acid). Limestones are unaffected by fluorine, zinc, copper, barium, etc., on account of the relatively low percentage of these elements present. The magnesia content in a limestone is variable.

Calcite is chemically pure calcium carbonate; magnesite is pure magnesium carbonate; dolomite is composed of a molecule of calcium carbonate and one of magnesium carbonate i. e., 54.65 per cent. of the former and 45.35 per cent. of the latter. Limestones have been divided into high calcium limestones and high magnesium limestones. The following outline will show the present scheme of classification:

CALCITE. ($CaCO_3$) (100%)	DOLOMITE. ($CaCO_3$ 54.65%) ($MgCO_3$—45.35%)	MAGNESITE. ($MgCO_3$). (100%).
$MgCO_3$ between 5% and 45.35%. (Dolomitic limestones).		$MgCO_3$ between 45.35% and 100%. (Impure magnesites).

As the outline shows, limestones containing magnesium carbonate from 5 per cent. to 45.35 per cent. are termed dolomitic limestones, while those whose magnesium carbonate contents are above 45.35 per cent. are termed impure magnesites. The former type are by far the most abundant. Beds of pure dolomite are uncommon in comparison with those of dolomitic limestones.

A chemical distinction between a pure limestone and a dolomitic limestone can be made by comparing their solubilities in hydrocholoric acid. The pure limestone effervesces at once in cold hydrochloric acid, whereas the dolomitic limestone or dolomite dissolves in hot acid only. High magnesium limestones are usually coarsely crystalline in texture, but this is not always the case. In some the texture may be very finely grained and compact.

Relation of Limestone to Soil in York County.

Limestone soils are often the basis for great agricultural centers. This is true of the "York Valley" in which the predominating rock is limestone, the action of which upon the soil makes this valley an unusually rich agricultural region.

Uses of Local Limestones.

Limestone finds many uses in the world of industry and is one of the most important rocks with which we have to deal. It was used for various purposes many centuries ago and some of the early uses continue to the present time.

Generally, limestones are used for manufacturing lime, cement and hydrate; as a flux in many industries; as a fertilizer; as ballast for railways and railroads; in making concrete; for macadamizing purposes; for curbing, paving and flagging; crude or undressed limestone is used for foundation work in buildings; it is used as a water softener; in sugar refineries; paper mills, glass factories, carbonic acid plants, alkali works, for decoration, etc., etc.

Locally it is used for cement, lime, fertilizer, macadam, ballast, flux, hydrate, concrete and building stone. For convenience the uses can be divided into four classes, viz:

1. Limestones used for structural purposes—Concrete and foundation stone.
2. Limestones used for road metal—Macadam and ballast.
3. Limestone used for burning—Lime, hydrate and cement.
4. Limestone used for chemical and agricultural purposes—Flux and fertilizer.

The following table shows the uses of the local limestone with the number of quarries producing material for each respective use:

Uses of product.	Number of Quarries Producing.
Ballast,	6
Concrete,	8
Building,	6
Macadam,	9
Cement,	2
Lime,	9
Hydrate,	1
Flux,	2
Fertilizer,	2

It will be seen from the above table more quarries are producing limestone for lime, cement and hydrate than for any other purpose. The limestone occurring in those quarries are of exceptional purity and therefore can be satisfactorily used for such purposes. In some

quarries the beds of limestone are impure yet easily quarried, thus making it profitable to work them for ballast, macadam, building stone and concrete.

Where the purer limestones are quarried, in pieces too small for calcining, they are used for fluxing in the iron industry and as fertilizer. Limestones are not very commonly nor extensively employed for this latter purpose, since it has been found by experiment, that twice the amount of finely pulverized limestone as of lime is required to produce the same result. It also requires a longer period of time to properly act, this being, in most cases, a disadvantage.

Ballast is a term given to all kinds of stone used for making the roadbed of railways and railroads. Some of the rocks used, other than limestone, are "trap," granite and gneiss spalls and sandstone.

Concrete is a mechanical mixture of some rock, such as limestone, "trap," etc., with sand and cement, in proper proportions. The stone ingredient is used in sizes from three-quarters of an inch to two or three inches in diameter. For heavy work, the sizes may reach six inches to eight inches.

Macadam is a term derived from the fact that in 1820 Mr. L. Macadam invented a pavement of broken stones for suburban and country roads. This invention was based on the property possessed by freshly broken stone to become compacted and in some cases cemented together, by the grinding and impact of wheels. A varied number of stones can be used for this purpose, which fact is economically important, as the stone for macadamizing a road must be obtained from local sources, owing to the high cost of transportation.

Lime is the solid resulting product obtained upon the calcination of limestone. The other compound, known as carbon dioxide, is in most cases allowed to go to waste.

Portland cement requires limestone containing 95 per cent. of calcium carbonate or higher and not over two or three per cent. of magnesium carbonate. Limestones containing 85 per cent. calcium carbonate can be used providing the magnesium carbonate contents are within proper limits and the silica and alumina are in proper proportions.

Hydrate. When limestones are used for making hydrate they must be of high purity and must slake readily and uniformly after burning.

Flux. Limestones commonly used for fluxing are required to be especially pure and uniform in composition. They must contain practically no silica, phosphorus, sulphur and very little magnesia. As a flux in glass making they must be very pure and must likewise form easily soluble double silicates, with potash, soda or some other base. In the making of paper, a high grade magnesium limestone is

required to give the high magnesium lime used. Magnesian limestones are extensively used for their magnesia contents, which compound is used for many purposes, one extensive and well-known use being in the steel industry.

QUARRYING.

In quarrying limestone, the opening or prospect should be so located that the least possible stripping is required. One quarry in the York Valley region requires a large amount of stripping, but in this case the clay to be stripped is economically used in the manufacture of brick. In many cases the use of the overburden of clay for this purpose is objectionable, in that it contains particles of limestone, which, when the clay is converted into bricks, are calcined to lime, and when the finished bricks are exposed to atmospheric conditions, this lime, absorbing water and carbon dioxide, expands, causing the brick to crack and often to disintegrate.

The limestone is blasted down in benches or levels and the rock is then further broken up by men along the working face into sizes suitable for handling. After this it is loaded on cars, which in turn, are raised from the quarry to the crusher or kilns by means of a cable and hoisting drum, operated by steam or electricity. The stone is emptied into the crusher and after it is crushed to the required size is fed beneath the crusher to a belt or chain conveyor, to which are attached, at regular intervals, small iron buckets or scoops. These buckets convey the material to the screens which are usually made of perforated sheet-metal (steel), and vary both in size and the number of perforations or rings. These screens revolve and in so doing allow the screened material to fall into storage bins or chutes, divided into separate compartments, each of which contains material of a different size. These chutes are inclined to allow the material to pass out through outlets in each respective compartment. Each outlet is about one foot high and is kept closed by means of a sheet-iron plate to which is riveted a handle. These plates can be raised and lowered by means of the handles. Cars or wagons are run beneath the chute, so that by raising the plate, the required amount of material is discharged into them. The handle is then pressed down and the plate closes the outlet. Another method of raising and lowering these plates is by means of a pulley, rope or chain, to one end of which is attached the plate and to the other end a heavy weight. In raising the door, pressure downward is applied to the weight, while in lowering it, the weights are forced upwards. The door and weights are so made that they balance one another.

Summarily, the quarrying of limestone requires the following operations·

a. Stipping the overburden.
b. Drilling.
c. Blasting.
d. Shaping the limestone for convenient handling.
e. Loading.
f. Hoisting to the kilns or crusher.

Drilling is making holes in rocks to receive the explosive used in blasting. The drills used are either round or hexagonal in cross section, made of steel, cut to any desired length. One or both ends may be forged into a cutting edge and so hardened by tempering that it will penetrate the rock, doing this either by a rotary motion of the drill or by the chipping of the rock into fragments by blows. Drilling is carried on by hand, steam, compressed air, or electricity. Locally, steam and compressed air drilling are resorted to.

Hand drilling is simple but slow. In one quarry one man did the drilling, but in most cases, one man holds the drill and partially revolves it after each blow, or in some cases two blows, if two men are doing the striking.

Drills operated by steam and compressed air strike from 300 to 500 blows per minute, which blows are more powerful than the hammer blow made by hand. The drilling bits have cutting edges of various forms, but the use of any particular form is entirely at the option of the driller, who should know what cutting edge will be most suitable for the rock he is drilling.

Steam drills can often be operated by one man, although in many quarries two men are required. The drill sets on a tripod and the entire outfit can be conveniently moved from place to place, as it can readily be taken apart. Air hammer drills are small and conveniently handled by one man.

Blasting is the loosening of rock by means of explosives applied in holes along the face of the quarry. The direction of a blast is determinded by the direction of the lines of least resistance in the rock. Blasting tends to loosen large boulders or masses, sometimes shattering them, so that with a severe blow of a sledge-hammer they will fall apart. Again, they must be broken up by further blasting. Three ways of breaking up the large masses are employed, namely:

a. Block-holing.
b. Mud-capping.
c. Undermining.

The first method consists in drilling a shallow hole in the rock and exploding a small charge of high-power explosive in the hole. The second method is performed by firing some dynamite on top of the rock, the dynamite being covered with a quantity of earth or wet-

clay (mud). The third method consists of boring a hole in the ground beneath the boulder and firing a charge of dynamite in the hole. The first two methods are most commonly employed.

Two kinds of explosives are used in local quarrying namely: Dynamite and black powder.

Dynamite having a strength of 40 per cent. is generally used in quarrying stone for ballast, macadam, etc. Among the common types of explosives used may be mentioned Atlas, A and B, Giant Powder No. 1 and No. 2, Carbonite, Hercules and Vulcan. Below are tabulated the relative composition of each of the above mentioned explosives:

	Atlas. A.	Atlas. B.	Giant. 1.	Giant. 2.	Carbonite.	Hercules.	Vulcan.
Nitro-glycerine,	75	50	75	40	25	40	30
Wood fibre,	21	14					
Sod. nitr.,	2	84	1	40	34		52.5
Potas. nitr.,						31	
Mag. carb.,	2	2			0.5	10	
Sod. carb.,			0.5				7.
Sulphur,				6			
Powd. res.,				8			
Diat. earth,			24.5	8			
Pot. chlor.,						3.34	
Sugar,						15.66	
Charcoal,							10.5
Wood meal,					40.5		
Total,	100	100	101	102	100	100	100

The operations necessary for blasting with dynamite are:

a. Boring or drilling the hole.
b. Cleaning out the sludge.
c. Placing the cartridge, or charging.
d. Placing the detonator into the top of the cartridge, or "priming."
e. Attaching the fuse to the detonator and crimping the fuse.
f. Filling the hole partly or entirely above the charge with mud or some suitable material, known as "tamping."
g. Firing the charge.

When dynamite and allied explosives are used, the charge, after being placed in the hole, is set off by means of a detonator, which is usually a copper capsule, inclosing from three to twelve grains of mercury fulminate together with one to four grains of potassium chlorate. The fulminating mixture is compressed in the end of the copper capsule and is then covered with some material, as collodion, shellac, or paper to prevent leaking. These detonators are exploded either by electricity or by a fuse. Upon exploding, they generate a very high temperature and also cause an extremely violent shock.

which latter is chiefly relied upon to start the detonation of the explosives used.

An electric detonator is one in which a piece of platinum wire is compressed into the detonating mixture, the ends of the wire being attached to copper wire wound around with cotton or asbestos insulation and leading out through a hard plug of sulphur and ground glass, which fills the capsule. On turning on the current, the platinum resistance wire is heated above redness and thus explodes the fulminate.

In using black powder, the following operations are necessary:

a. Drilling and cleaning out the holes.
b. Filling with powder.
c. Inserting fuse in powder.
d. Tamping.
e. Firing.

When used, black powder is charged with a long stem, that it will reach the bottom of the hole without touching its sides above the charge limit. In some cases the powder is put into small paper bags and these are closely pressed into the bottom of the hole. When in loose form, the fuse is inserted into the powder, but when in bags it is tied to the last bag put in the hole.

Haulage and Hoisting.

After the stone is blasted down, it is broken into sizes suitable for convenient handling. The cars or skips are loaded by hand.

The skips or cars used for conveying the limestone from the quarry to the crushers and kilns are constructed of steel or wood and are square or oblong in shape. They are hoisted up an incline by means of a cable attached to one end of the skip or car, the other end being wound around a hoisting drum, operated by electricity or steam. The cars may be emptied by removing one side and inclining the car automatically, or by hand, or through the bottom which in such case, consists of two plates that swing on hinges attached to the sides of the car. The crusher may be placed directly beneath the track or it may be to one side.

In one plant in this district, the quarried limestone is hoisted to the surface by means of an overhead aerial cable-way, this is due to the fact that the quarry is one of the pit type and very deep.

Handling--Crushing.

Two types of crushers, the jaw and gyratory, are used, the former type being represented by the Blake, Farrel, Champion, Krom and Climax; the latter, by the Gates and Symons. These crushers are

used for preparing limestone to be used as ballast, macadam, concrete, flux, etc. The Williams Patent Pulverizer is used for fine crushing and pulverizing limestone to be used for fertilizing purposes. The Krom and New Century rolls and the Symons Disc Pulverizer are also used for fine crushing.

Screening.

Below are tabulated the various sizes to which the local limestone is crushed:

Use.	Size.
Ballast,	1¼"—1½"—2"—3".
Concrete,	¾"—1"—1¼"—1½"—2"—6"—8".
Building,	16"x8"x8" or larger.
Macadam,	¼"—⅜"—½"—3".
Cement, Lime, Hydrate,	Material for cement, lime and hydrate 8"x8"x6" or larger.
Flux,	¼"—½"—1"—2"—2½".
Fertilizer,	1/5"—1/10"—1/40" or larger when not prepared.

Crushing tends to break the material into various sizes and in order to sort the crushed stone, it must be screened. The screens used for this purpose are sheet-steel cylinders, perforated throughout with holes of a single mesh, or else they are divided into sections each section having larger perforations than the one preceding. Another type is one in which there are three screening surfaces, one inside of the other. The screen having the largest mesh is the one in the center, the one with a smaller mesh, next to it, and so on. These screens are sloped at a slight angle, thus allowing the material to be discharged by gravity. In case a single screen is used three divisions are usually required. The material is fed in at one end of the screen and moves toward the opposite end. The first screen allows the finest material to pass through, the oversize from it, passing to the second screen, which separates the middle sized material, allowing the oversized material from the second screen, to pass onto the third screen, through which it is sieved, the oversize from this screen being discharged at the opposite end, thus making four sizes of material. The screens revolve slowly and may operate on roller bearings or by belt drive and shafting, the latter running through the center of the cylindrical screen, and in case there are two or three screening surfaces each one is keyed to the shaft by ribs, riveted on each section.

The screens may be operated by steam or electricity, and in case the latter is used, the motor used to operate the crusher is often the same one used to operate the screens, as well as the conveyors and elevators.

Drainage.

Drainage of the quarries is commonly carried on by means of steam pumps, both simple and compound, with single or double cylinders. In some quarries drainage is carried on by means of a bucket elevator, driven by electricity or steam. The buckets are made of galvanized iron and are attached to a chain belt. On the downward movement of the elevator, the buckets are inverted so that on the upward movement they will "scoop up their fill" of water, and discharge it into a trough on the following downward movement of the conveyor.

Cost of Quarrying.

The cost per ton of limestone is based upon certain standard facts and items as:

1. Cost of stripping the overburden.
2. Cost of quarrying.
    - *a.* Wages of quarrymen.
    - *b.* Explosives, as powder, dynamite, fuse, caps.
    - *c.* Repairs on tracks, cables, machinery, etc.
    - *d.* Sharpening drills.
3. Cost of haulage or transporting limestone to the markets.

All these items vary to greater or lesser extent with each quarry. The total cost per ton of stripping, quarrying and hauling the limestone, will vary from 20 to 35 cents. Long haulage will increase this cost. A heavy overburden often necessitates abandoning a quarry of excellent quality. The average cost for transporting limestone from the quarry to the kiln should not be more than 10 cents per ton, but including stripping, etc., this cost often approaches 30 cents.

Methods of Packing, Shipping, etc.

In this district, most of the plants are located along or very close to the Northern Central Railway or the Western Maryland Railroad, which fact facilities haulage and thereby lessens the cost of marketing. The quarries that are not so situated have in some cases railroad sidings running into the yard of the plant; in other cases the material must be hauled from the plant of the quarry by wagons or electric railway cars.

Units of Measurement.

Since limestone finds so many varied uses in the arts, there is no general unit of measurement in use. It may be sold by the cubic foot, cubic yard, ton, cord, square foot, square yard, etc. In this

district it is usually sold by the ton, either long or short, perch and cubic yard. A cubic yard of limestone (solid) weighs between 3,800 and 4,600 pounds, but when purchased in bulk, the "voids" cause a decided decrease in weight. The weight of cubic yard then varying between 2,300 and 3,000 pounds.

The following Table *a*, shows the output of limestone for smelter, open-hearth and blast furnace flux, in 1908, 1909 and 1910, in long tons (2,240) pounds):

Year.	Quantity (long ton).	Value.	Ave. price per long ton.
1908,	4,350,381	$2,324,173	0.53
1909,	6,593,822	3,165,872	0.50
1910,	7,545,094	3,755,060	0.51

The quantity of limestone used for crushed stone, in road making, concrete and railroad ballast, far exceeds that used for any other purpose. The average price (throughout the United States) per short ton was, in 1908, 56 cents; in 1909, 57 cents and in 1910, 55 cents. In 1908, 1909, 1910, Ohio ranked first in production of limestone for the above-named purposes; in 1908, 1909 and 1910, Illinois ranked second; and in 1908 and 1909 Pennsylvania ranked third; but in 1910 fell to fourth place.

The following table shows approximately the quantity in short tons and value, of crushed stone (total for all purposes), during 1908 *b* and 1910 *c* produced in Pennsylvania.

Year.	Quantity* (short tons).	Value.	Ave. price per short tons.
1908,	2,453,077	$1,373,723	0.56
1909,	2,683,079	1,529,355	0.57
1910,	2,472,629	1,359,946	0.55

a. U. S. Geological Surv., Min. Res., Part 2, 1909.
U. S. Geological Surv., Min. Res., Part 2, 1910.
b. Loc. Cit.
c. U. S. Geological Surv., Min. Res., Part 2, 1910, pp. 666.677.
*NOTE:—These figures are only approximate and are the results obtained by dividing the total value of the Pennsylvania output by the average price per ton, which latter is the average price for the total output of the United States.

Statistics.

The output of limestone for all purposes, excepting that of lime manufacture, and to a lesser extent, for use in the manufacture of Portland cement, *(a)* has steadily increased since the year 1907.

Owing to the resumption of operations in the steel industry much of the increase in the total output was caused by the utilization of the limestone for fluxing purposes. In the past six years, Pennsylvania has exceeded any other State in the annual output of limestone and below are tabulated the statistics for the years 1908, 1909 *(b)* and 1910 *(c)*:

Uses.	Value 1908.	Value 1909.	Value 1910.
Rough, building,	$80,222	$104,930	$103,295
Dressed, building,	13,388	1,410	118
Paving,	128,454	124,521	67,069
Curbing,	9,930	2,128	1,850
Flagging,	1,413	1,250	1,108
Rubble,	24,239	2,283	3,314
Riprap,	7,716	709	1,714
Road making,	653,503	596,503	409,643
R. R. ballast,	300,702	444,091	495,002
Concrete,	419,518	489,241	455,301
Flux,	2,324,173	3,165,872	3,755,060
Sugar factories,	20,034		
Other uses,	74,719	140,767	121,137
Total,	$4,058,011	$5,073,225	$5,394,611

Lime.

Lime is the solid product remaining after completely calcining limestone, the carbon dioxide, originally combined with the lime to form the limestone, being driven off as a gas in burning.

Classification of Limes.

There are numerous methods of classifying limes, but all of them are based upon the same general principle. As example, I shall quote the schemes of classification proposed by Gen. Q. A. Gillmore. (Ref. 19).

a. Common or fat limes; those containing less than 10 per cent. of impurities.

b. Poor or meagre limes; those containing free silica (sand), etc., up to amounts varying between 10 per cent. and 20 per cent.

c. Hydraulic limes; those containing impurities in amounts varying from 30 per cent. to 35 per cent.

d. Hydraulic cements; those containing as high as 60 per cent. of impurities.

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a. Limestone used for making Portland cement; U. S. Geol Su.rv., Min. Res. Part 2, 1909, pp. 433-453.
b. Limestones used for other purposes: U. S. Geol. Surv., Min. Res., Part 2, 1909, pp. 598-602.
c. U. S. Geol. Surv., Min., Part 2, Res. 1910, pp. 666-667.

The scheme proposed by Burchard is (Ref. 20, p. 545)

a. High calcium limes, containing over 90 per cent. of lime.

b. Magnesian limes, containing from 5 per cent. to 25 per cent. of magnesia; the remainder being lime.

c. High magnesian limes, to dolomite limes, containing from 25 per cent. to 45 per cent. magnesia the remainder being essentially lime.

Physical and Chemical Properties of Lime.

Lime or quicklime, as it is often called, is when pure and in lump form, a fine, white, porous compound, with a specific gravity, varying in the pulverized product, from 3.09 to 3.15 and in the lump product, somewhat lower, owing to the porosity of the mass. Accordingly, a cubic foot of powdered lime weighs approximately 195 pounds, while that of lump lime varies between 170 and 182 pounds. A bushel of lump lime weighs between 70 and 75 pounds, the accepted legal weight in Pennsylvania being 72 pounds; (these weights being taken directly after the lime has been drawn from the kiln.)

The fact that lime is highly porous will cause it to absorb moisture and carbon dioxide from the atmosphere and thus to "air-slake" a process which causes rapid disintegration, the resulting mass being a fine white powder, composed of some calcium carbonate, calcium hydrate and possibly some basic carbonate, unfit for further use, in making mortar, etc. Lime should be kept in lump form after having been drawn from the kiln as there is less danger of air-slaking, excepting on the external surface of the lumps. The purer the lime, the more rapid will be the air-slaking and final disintegration, although these properties largely depend upon the porosity of the stone.

W. E. Emley has found that in crushing and tensile-strength magnesian limes are stronger than high calcium limes. He also observed that in burning a limestone, a considerable portion of the lime combines with the impurities to form calcium silicate, calcium aluminate and calcium ferrate, these compounds being valueless in many cases and causing thereby a loss in the lime-acting qualities.

Eckel (Ref. 21, pp. 995-9), compares the results obtained upon the slaking of high calcium and magnesian limes as:

High Calcium Limes.

a. Slake rapidly.

b. Expand greatly.

c. Evolve heat on expansion and the formation of calcium hydrate or slaked lime.

d. Yield a large bulk of slaked lime.

e. Rarely carry less than 90 per cent. of lime, commonly 95 per cent. and higher.

f. Rapid and incomplete absorption of moisture and carbon dioxide causes weakness.

Magnesian Limes.

a. Slake very slowly.

b. Expand less than high calcium limes.

c. Evolve very little heat and form a compound of calcium hydrate and magnesia.

d. Yield less bulk of slaked lime.

e. Carry from 10 to 30 per cent. of magnesia.

f. Slow absorption of moisture and carbon dioxide results in a stronger base for mortar.

Effect of Impurities on Lime.

Some limes are very pure; others contain many impurities, such as silica, alumina, ferric oxide, clay, etc. These impurities are detrimental when pure limes are required, but when present in very low percentage, are neglected. Clay, ashes, etc., cause the lime to present a dirty gray color when drawn from the kiln, and this is a serious drawback when used for high-grade plasters and mortars. Any iron compound present causes a distinct yellow-gray to brown coloration. Again, a relatively small amount of impurities (magnesia excluded) will cause very slow slaking, a very important operation in preparing and utilizing mortars. Magnesia is invariably present in all lmes but is not classed as an impurity, as it possesses properties similar to those of lime.

When mixed with water lime slakes to form a new compound called "slaked lime," or calcium hydrate. In so doing much heat is evolved and the temperature often rses to 150° C (302° F), sufficient to char wood. From this it is apparent lime should never be stored for any length of time in wooden bins or cars, or where water can reach it. If sufficient water is added, part of the lime will form insoluble calcium hydrate, while a certain portion will dissolve to form the "lime water" of commerce. Both slaked lime and lime water rapidly absorb carbon dioxide from the atmosphere and thereby again form calcium carbonate or artificial limestone.

Uses of the Local Product.

The local production of lime (Ref. 20, p. 546) is used in the manufacture of fertilizer, cement, hydrate, plaster, mortars, whitewash and as flux in the manufacture of glass; and in paper-making.

When limes are used as fertilizer, the amount necessary varies with the composition of the soil, and as the lime is basic in action, it acts as an excellent neutralizer in highly acidic soils (Ref. 22).

In the manufacture of Portland Cement, near York, lime from one quarry is extensively used and being of exceptional and uniform purity, is a valuable product. As is well known, Portland Cement is a mixture of pure, non-magesian, limestone or lime, with a certain

definite amount or argillaceous material, the two being burned together at a high temperature. The resulting fused clinker, consisting of calcium silicate, calcium aluminate and calcium ferrite or ferrate, is ground to a very fine powder, which is capable of slaking and setting under water.

Lime used for making hydrate must be comparatively pure, easily capable of slaking and the finished product must be thoroughly slaked. For making *plasters,* lime should be tested for time of setting. pasticity, hardness, color and constancy of volume (Ref. 23, pp. 192-4) In making *mortar,* lime is mixed with sand, in certain definite proportions, which result in a compound having certain setting as well as cementing properties. W. E. Emley (Ref. 20, pp. 617-620) says "building lime should be tested for crushing-strength, tensile-strength and sand carrying capacity." As a whitewash for fences, houses, barns, stables, etc., lime is mixed with a sufficient quantity of water to allow it to be applied with a brush and at the same time adhere properly.

For *glass making,* lime must be of exceptional purity, so as to form, together with some other base, as soda, or potash, an easily fusible double silicate. In the manufacture of *paper,* a high-grade magnesian lime is required. It must be free from iron oxides or silica and should run very high in magnesia. Magnesia obtained from magnesium carbonate is commonly employed for this purpose.

Burning of Lime.

Lime-burning has been carried on for many centuries and its chemical nature and general reactions are very simple. Calcination, or the dissociation of the limestone into its components, takes place at approximately 750 C., but complete dissociation does not take place until a temperature of approximately 900 C. or higher (1,316 C) is obtained. Generally speaking, the chemical reactions taking place in burning a limestone are for a pure or high calcium limestone and for a high magnesian limestone, as follows:

a. $CaCO_3$ plus heat (low) equals CaO (lime) and CO_2 (Carbon Dioxide).

b. $CaCO_3$ plus heat (high) equals CaO, CO_2, various silicates, aluminates and ferrites or ferrates.

c. $xCaCo_3$. $yMgCO_3$ plus heat (low) equals xCa&O, yMgO and $xyCO_2$.

d. $xCaCO_3$.$yMgCO_3$ plus heat (high) equals xCaO .yMgO ,$xyCO_2$ and various silicates, aluminates, ferrites or ferrates.

In equation (*a*), the limestone is broken up by the heat into lime and carbon dioxide, the limestone, in this case, possessing a definite composition. In equation (*b*), the limestone, by more intense heat

is broken up as in equation (*a*), but certain compounds are formed by the action of a higher temperature. In equation (*c*), the magnesian limestone, upon heating to a comparatively low temperature breaks up into magnesia and lime, the entire carbon dioxide being driven off as a gas. Finally, equation (*d*), is similar to equation (*b*), but the presence of magnesia tends to form new compounds with any silica, alumina or iron present, such compounds being silicates, aluminates, ferrites or ferrates of magnesia, in addition to similar compounds of calcium. The resulting material from a process involving equation (*a*) or (*c*), is compact, homogenous and has the same shape as it had prior to calcining, whereas, the resulting product formed by equation (*b*) and (*d*) are in semifused condition when drawn from the kilns.

Experience in lime-burning has shown that the carbon dioxide primarily expelled in the cooler portions of a kiln interferes with the expulsion of that coming off from the hotter parts of the kiln, and that the "quarry water" present in the limestone, being evaporated into steam, will combine with the dioxide in the top of the kiln, thereby diminishing the pressure and facilitating the escape of the remaining dioxide. Where no "quarry water" is present, steam or vapor is injected into the kiln and produces the same effect.

Next to be considered is the action taking place on the impurities in the burning of limestone into lime. The compounds usually present are calcium and magnesium carbonate, iron oxides, pyrite or iron disulphide, some iron carbonate, silica, clay, various silicates, organic matter and "quarry water." Upon properly burning, the organic matter is decomposed and expelled; the quarry water, driven off; silica, silicates and clay, remain unchanged; pyrite is converted into ferric oxide and sulphur dioxide, which later passes off as a gas; calcium, magnesium and iron carbonates are calcined, the carbon dioxide being expelled, lime, magnesia and ferric oxides remain. If too high a temperature is attained, which is often the case in thorough lime-burning, any clay, silica or silicates will fuse to a clinker, which is undesirable.

W. E. Emley says that the more porous the limestone, the more easily it will calcine. Other impurities found in local limestones, such as sphalerite, barite, gypsum, and fluorite, occurring in very minor quantities, are more or less inert; the gypsum loses its water of crystallization and becomes "dead burned" while the sphalerite is converted into zinc oxide, zinc sulphate and sulphur dioxide.

Impure limestones are difficult to calcine uniformly. A limestone, containing much silica as sand, will often vitrify, at a temperature not much above dull red heat. This vitrification will hold back the calcination of the limestone in the centre of the mass, the vitrification

taking place on the surface of the lumps. Impure clayey (argillaceous) limestone, when burned, usually forms silicates (clinkers).

From experience, it has been found that a pure lime should be rapidly calined as it will slake much better. Compact limestones cannot be so readily calcined as porous ones, but yield a far superior lime. In burning, lime expands from 20 per cent. to 30 per cent. in volume and yet retains the shape of the limestone before calcining. Incompletely calcined lime forms a basic carbonate and is termed "dead" and is incapable of slaking with water.

W. E. Emley (Ref. 23, pp. 68-69) assistant chemist in the Bureau of Standards, at Pittsburgh, Pa., together with A. V. Bleninger, has found that the greatest temperature allowable in burning a pure calcium limestone is above 1,316 C.; for an impure high calcium limestone, 1,037 C. to 1,205 C.; impure magnesian limestones, 1,000 C. to 1,038 C.; and of pure magnesian limestones, 900 C. to 1,038 C.

Types of Kilns.

Before proceeding to describe the types of the kilns used in this district, it will be well to tabulate (Ref. 21, pp. 101-3; 475-5) the types of kilns and the fuels in general use:

A. Intermittent kilns—Those requiring calcination and removal of one charge before the introduction of another.

Type: Set kiln.
Fuel: Coal, coke and wood.

B. Perpetual or continuous kilns—Those in which the first calcined portions can be removed and fresh charges introduced while the calcination is in progress.

1. Ordinary draw-kiln—In which the limestone and fuel are in contact and are introduced in alternate layers into the kiln.
   Type: Schöfer (Aalborg) kiln.
   Fuel: Coal and coke.
2. Patents flame kiln—In which the limestone and fuel are separate, the former being charged into the kiln; the latter being burned in separate compartments, outside of the kiln.
   Type: Keystone (Ref. 21, pp. 104-5) lime kiln.
   Fuel: Coal, coke, gas.

Intermittent kilns are used for burning lime both in localities without railroad transportation, where the demand is irregular and small and the output used mainly for agricultural purposes, and in districts where output and transportation are facilitated by railroads and the lime is produced on an extensive and commercial scale.

In York County numerous such local kilns are in use, but irregularly. One near Myer's mill and another near Rudy's mill along the

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Codorous Creek (about $4\frac{1}{2}$ miles N. W. of York), are operated for about three months during the year and the product used for fertilizing, whitewashing, etc., in the immediate vicinity.

These old-time kilns were constructed of stone and so located on the side of the hill that the top of the kiln could easily be charged. In charging (some large pieces of limestone were formed into an arch in order to support the mass of overlying smaller material, which was charged upon it. A wood fire was started under this arch, the heat being gradually raised, in order to prevent any sudden expansion and final break-down of the arch. When a bright heat was obtained it maintained for a few days and then the charge was ready for removal. A large shrinkage of volume in the kiln showed that the burning was complete. The filling-in or choking-up of spaces between the larger fragments and the fact that an iron rod would easily peretrate the mass, likeswise proved burning to be complete. The fire was allowed to die out and the lime after cooling was drawn from the kiln.

An improvement was made by lining the kiln with fire-clay or brick. The improved kiln, known as the "set" kiln was elliptical, tapering slightly. A kiln 10 feet to 11 feet in its greatest diameter, was 25 feet to 28 feet in height; five feet to six feet in diameter at top and seven feet to eight feet at the bottom. An iron grating was used, upon which fuel was burned, this grating being from one foot to two feet above the bottom of the kiln. The heat loss was very great, owing to the heating of the kiln, brick walls and the stone, each time a charge was introduced. The stone nearest the arch was very likely to become "dead-burned," whereas, that at the top would be but partially burned. These kilns are being largely replaced by shaft kilns of various types, encased in a steel shell. Some few of the old type remain, where local demand alone is required. They may be operated for a few weeks or months, and remain idle for the rest of the year.

Plates XIV and XV show the "set" kiln and a modernized type of "draw" kiln:

Dimensions of Klns. Set Kiln.	Interior dimensions.
Diameter of kiln at top, ...	6′
Diameter of kiln at center, ...	8′
Diameter of kiln from top of door to opposite wall, ...	7′
Width of kiln-casing from side to side, ...	40′
Depth of kiln-casing from front to back, at top, ...	30′
At bottom, ...	26′
Height of kiln from base to top, ...	25′
Height of kiln from top of brick base to kiln top, ...	[illegible]

Height of door (outside) from base of kiln to top of door, ...	10′
Height of door (inside) from base of kiln to top of door, ...	7′
Height of door, ...	5′
Width of coping, ...	2′

Modernized Draw Kiln. (Emigsville).

Width of casing at top from side to side, ...	48′
Width of casing at bottom from side to side, ...	51′
Thickness of kiln-coping, ...	1′6″
Height of kiln from base to top, ...	25′
Height of kiln from hearth to top, ...	23′
Diameter of inside of kiln, at top, ...	7′
Diameter of inside of kiln, 18′ from top, ...	6′
Diameter of inside of kiln, 20′6″ from top, ...	4′
Diameter of inside of kiln, 23′ from top, ...	1′8″
Width of door, at bottom, outside, ...	7′9″
Width of door, at bottom, inside, ...	4′
Height of door, outside, ...	7′9″
Height of door, inside, ...	6′6″
Height of eye-hole, ...	1′11″
Width of eye-hole, ...	1′6″
Thickness at top of front retaining wall, ...	1′6″
Thickness of bottom of front retaining wall, ...	3′
Height of front retaining wall, ...	25′
Thickness of top of east and west retaining wall, ...	1′6″
Thickness of bottom of east and west retaining walls, ...	2′5″
Height of east and west retaining walls, ...	15′

In starting a "draw" kiln, fuel is first placed at the bottom and it is then filled two-thirds full of stone, when a layer of shavings and wood, three inches thick, is introduced and ignited. Coal is added and then a layer (thin) of stone. When burning well, another layer of coal is put above the layer of limestone and then alternate layers of coal and stone are continued until the kiln is full. Flames appearing near the top of the kiln show that the draught has commenced and that the alternating lays of stone and coal are to be continued. The first lime is drawn in about a week.

The vertical distribution of heat in the old type of kiln, is very uneven and therefore the kilns are usually not very high. Their capacity in this district varies from 500 to 1,800 bushels, in each case depending upon the size of the kiln. Frasch (Ref. 24), says that such kilns require from two to three volumes of hard wood per volume of lime.

Numerous types of continuous kilns are in operation at the present time, such as the Hoffman, Schöfer (Aalborg), and the Keystone.

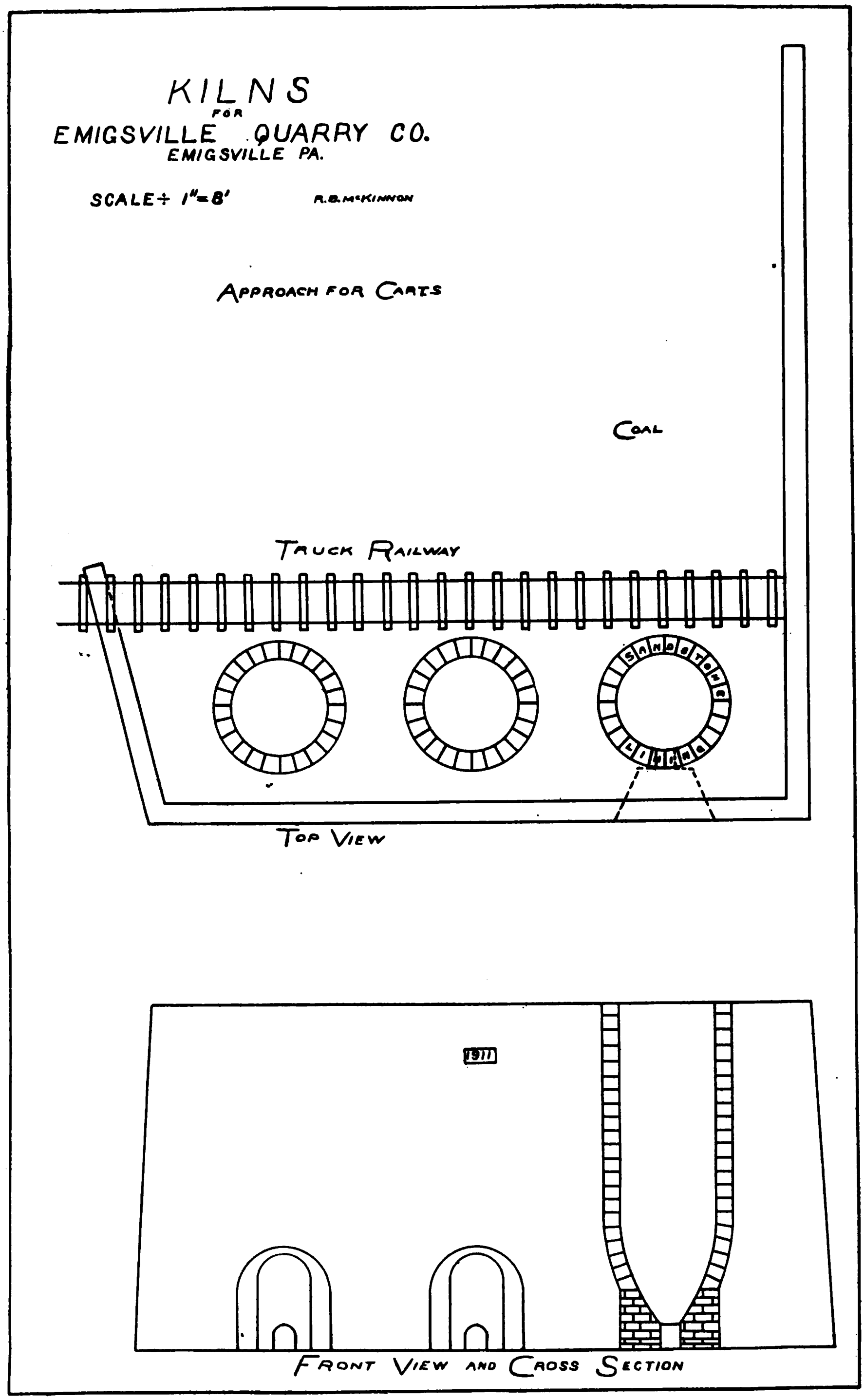
KILNS
FOR
EMIGSVILLE QUARRY CO.
EMIGSVILLE PA.
SCALE÷ 1"=8'
R.B. McKINNON
APPROACH FOR CARTS
COAL
TRUCK RAILWAY
TOP VIEW
FRONT VIEW AND CROSS SECTION

Plate XV.

The former is extensively used in Germany, but not in the United States. The Schöfer kiln is used in the manufacturing of Portland cement, while the Keystone is used in this district, being manufactured by a local concern. There are many other types of kilns, but they differ in construction, utilization of waste, heat, dimensions, methods of mixing the charge, etc., etc.

Vertical continuous draw kilns present many advantages and disadvantages over the separate feed or patent flame kiln. For convenience, these comparative advantages and disadvantages are tabulated:

Advantages.

A. Draw kiln with mixed feed.
 1. Economy in fuel.
 2. Cheaper to build.
 3. Yield a larger output than the same size "flame kiln."

B. Flame kiln with separate feed.
 1. More convenient to operate.
 2. Stone is more evenly burned.
 3. Lime is free from impurities introduced in the fuel.

Disadvantages.

1. Lime is discolored by contact with fuel.
2. Ashes from fuel may clinker the external portion of the material and thus prevent even and complete calcination.
3. Lime contaminated with ashes and separated with difficulty, resulting in a product of lower quality.
4. Greater fuel consumption.

The Keystone Patent Flame Kiln is a type of continuous kiln in which the stone and fuel are separated, this separation yielding a final product free from ashes and white in color, thereby resulting in the extensive use of this type of kiln. In general, the kiln consists of a steel shell, lined with fire-brick. There may be one or two furnaces attached to the kiln, heat from these being directed against the limestone, through openings between the furnaces and kiln-shell and lining. The cooling compartment is lined with fire-brick and is an inverted frustrum of a cone, suspended from a heavy cast-iron plate, which in turn, is riveted to the base of the kiln. It may be six feet to six and one-half feet in diameter at the top, according to the size of the kiln, but is usually about seven feet in height. The loaded cars are hoisted from the quarry and the limestone charged into the kilns through a charging-door at the top of each kiln. The burned lime is withdrawn by means of draw-gates, operated by hand-wheels, projecting outside the kiln. Cars can be run on a track beneath

these gates. Any heated air which accumulates around the cooling chamber, is discharged directly into the ash-pit, under the gates, thereby furnishing heated draught, which results in a greater efficiency of the furnace.

Cost of Lime Manufacture.

The *cost* of manufacturing lime is variable, owing to local conditions and lack of modern large plants. The principal items entering into the cost of lime manufacture are:

1. Interest on cost of plant and quarry.
2. Cost of quarrying the limestone.
   (*a*) Proximity to kilns.
   (*b*) Proportion of unburned stone, unfit for use.
3. Cost of fuel for burning.
   (*a*) Character of burned stone, with respect to hardness, impurities, property of slaking.
4. Labor costs, exclusive of quarrying.

Further items are:

5. Cost of fuel for engines.
6. Incidental and contingent expenses.
7. Insurance on buildings and machinery.
8. Accident and delay.
9. Wear and tear.
10. Cost of transportation.
11. Cost of power.
12. Cost of selling.

The chief items necessary in estimating the cost of a lime plant and burning lime are:

1. Cost of equipment.
2. Cost of labor.
3. Cost of fuel.

Eckel (Ref. 21, p. 110) tabulates in general, the total cost of lime manufacturing, per short ton, as comprising:

1. Interest on cost of plant and quarry, ...	5 to 20c
2. Taxes, minor supplies, etc., ...	10 to 25c
3. Cost of quarrying two tons of limestone at 25 to 45c per ton, ...	50 to 90c
4. Cost of fuel (300 to 500 lbs.) for burning, ...	30 to 75c
5. Cost of labor, exclusive of quarrying, ...	25 to 80c
Total cost per short ton burned, in bulk, ...	$1.20 to $2.90

From the above table it will be seen that a bushel of lime, weighing 70 pounds, will vary in cost from 4.2 cents to 10.15 cents. It has

been found that one pound of coal is sufficient to make three pounds of lime.

Methods of Packing, Shipping, Etc.

The fact that lime cannot be safely stored in wooden receptacles, owing to its rapid slaking with water and the heat developed therefrom, necessitates rapid transportation, where wooden receptacles, such as box cars, wagons, barrels, etc., are employed. Great care must be taken to allow no water to come in contact with the lime.

Lime is usually shipped to the markets in bulk in closed freight cars or in barrels. Frequently paper sacks or bags are used.

Statistics.

In the annual production of lime for all purposes, Pennsylvania, has ranked first for many years. Below are the statistics for 1909 (*a*) and 1910 (*b*).

Year.	Quantity (short tons).	Value.	Ave. price (short tons).	No. of plants in operation.
1908,	582,352	$1,883,496	$3.23	443
1909,	885,299	2,532,454	2.86	635
1910,	877,714	2,440,850	2.78	572

PART III.

Hydrates

Hydrate or hydrated lime is the product obtained upon adding sufficient water to slake the burned lime. It is lime that has its affinity for water, satisfied. The chemical formula is $Ca(OH)_2$ or $CaO.H_2O.$, and is similar in its chemical formula to "lime water."

When burned lime, either high calcium or magnesian, is slaked upon the addition of water, considerable heat is evolved and much expansion takes place, both by formation of the new compound and the pressure or expansive force resulting from its formation. This heat causes evaporation of a quantity of water which must be considered when the water is added. The heat also tends to change the lime from an amorphous to a crystalline state.

(a) U. S. Geol. Surv., Min. Res., Part 2, 1909, pp. 544-5.
(b) U. S. Geol. Surv., Min. Res., Part 2, 1910, p. 611.

Magnesian limes do not slake as rapidly as high calcium limes and should contain not less than 30 per cent. of magnesia, nor more than five per cent. of impurities. There should be less than six per cent. of silica, alumina, ferric oxide and carbon dioxide, in a high calcium hydrate, therefore, a very pure limestone is required.

Hydrate is a fine, white, dry, fluffy powder. It does not absorb moisture from the atmosphere (except upon lengthy exposure) thereby causing blistering and peeling, as in the case of lime. It does, however, absorb carbon dioxide, but more slowly than lime. The specific gravity is 2.078. Theoretically, hydrate is a compound in which 56 parts of lime are combined with 18 parts of water, but all commercial limes contain silica, alumina, ferric oxide, magnesia, etc., and therefore the hydrate made from these limes will contain these impurities (magnesia excluded as an impurity) to a greater or lesser degree. This would make the theoretical requirement of water vary, and it is necessary in all cases to analyze the lime before hydrating, to determine the lime contents, from which the necessary equivalent of water can be calculated.

By experiment, it has been found that if the total bulk of water necessary for slaking a batch of lime is added at once, the lime will expand to 3½ times its original volume, while air-slaked lime increases in volume 1.7 times its original bulk. Likewise, one short ton of lime will yield 2,500 lbs. of hydrate.

All hydrate absorb carbon dioxide, but the carbon dioxide content. observed in an analysis, is due to the absorption of this gas by the burned lime prior to being hydrated. The following are two characteristic analyses of hydrate:

	(a)	(b)
$Ca(OH)_2$	90.11	83.13
CaO	......	1.87
$CaCO_3$	2.25	10.32
$Mg(OH)_2$	1.39	......
MgO	......	1.27
SiO_2	1.05	0.46
$Fe_2O_3Al_2O_3$	1.01	0.44
Hygroscopic moisture,	3.10	2.56
Total,	99.91	100.05

Impurities such as silica, alumina and iron oxides, in the hydrate, cause an uneven and rough surface, when used for plastering. Too much alumina and iron oxide are coloring materials and should be avoided. As before stated, in high calcium limes, the impurities should not exceed six per cent. while in magnesian limes, less than

30 per cent. of magnesia is undesirable with less than five per cent. of impurities.

Hydrate is superior to both calcium and magnesian limes, in that it does not:

a. Deteriorate rapidly.

b. Require handling prior to using, such as slaking, screening or ageing.

c. Can be safely stored in paper or cloth sacks, wooden boxes, barrels or cars.

d. Can be safely transported by water.

e. Is easily handled.

f. Is clean; there being no waste.

g. Is even to work, a benefit to the plasterer or builder.

The uses of hydrate are similar to those of lime. It is used as fertilizer, for making bleaching powder, in the manufacture of glass, powder, soap, paper, sugar, plasters, etc., as a water softener, for making sand-lime bricks and Portland cement, in chemical works, etc., etc. It can be readily mixed with cement, sand and gravel and acts as an excellent binder.

Manufacture.

In general, the materials used for manufacturing hydrate are freshly burned lime and water. The lime is first crushed and is then sprinkled with sufficient water to slake it. Great care must be taken to have sufficient water present to overcome the amount evaporated by the heat evolved, but at the same time to have a quantity sufficiently low to prevent any of the hydrate becoming pasty or damp. The resulting hydrate must be a fine, dry, white powder.

Few methods of hydrating are in use. The most important, however, are the Kritzer and the Clyde. In one method, the lime coming from the kilns is cooled and run through a crusher, after which it is elevated to the hydrator, which in this case, is continuous in action. After the material has been hydrated, it is elevated to a storage-bin, from which it is passed through a screening mill. From the latter, it is again elevated to a storage-bin, from which it is fed into an automatic bagging machine and is ready for shipment. In this district, hydrating is carried on at one plant, but the method is secret.

There are three stages in the manufacture of hydrate, viz:

1. Crushing the lime to a suitable size.
2. Thorough mixing of the lime with the proper amount of water, or hydrating proper.
    a. Sprinkling the lime with water.
    b. Constantly stirring or agitating the mixture until dry.
3. Separation of the hydrate from impurities of a physical nature.

Lime used for making hydrate should not be burned at a very high temperature, otherwise clinkering or sintering will result and this is a serious drawback in hydrating. The lime should be burned very slowly so as to prevent any such action. However, the purer the lime, the less clinkering will result owing to the lower temperature of burning.

Cost of Manufacture.

The principal items in estimating the cost of hydrating lime are:
a. Cost of plant and equipment.
b. Cost of fuel and lime.
c. Cost of power.
d. Wages.

Standard of Packing, Shipping, Etc.

The manufacturers of hydrated (Ref. 26) lime use a standard uniform package as follows:

"Bags: A heavy, closely-woven burlap or duck cloth bag, containing 100 pounds each, or 20 bags per ton; a paper bag or sack, containing 40 pounds each, or 50 bags per ton."

Statistics.

The following table gives the statistics for hydrate, in the United States, for the years 1908, 1909 (*a*), and 1910 (*b*).

Year.	Quantity.	Value.	Ave. price (short ton).	No. plants in U. S.	Plants in Penna.
1908,	136,441	$548,262	$4 02	46	11
1909,	207,611	913,150	4 40	51	10
1910,	320,819	1,298,789	4 02	52	8

PART IV.

Description of the Quarries and Associated Plants in the York Valley Limestone Belt.

Each quarry and associated plant in operation at the present time is described in the order given on the detailed map accompanying this report (Plate V).

(a) U. S. Geol. Surv., Min. Res., Part 2, 1909, p. 549.
(b) U. S. Geol. Surv., Min. Res., Part 2, 1910, pp. 616-7.

The descriptions bear entirely on the petrological character of the stone. In all cases, the minerals found in the quarries are very sparingly present and in no instant in sufficient quantities to lessen or affect the commercial value of the limestone. Dolomite is classed as a mineral, as well as a rock, but where classed as a mineral, it is in crystalline form.

Quarry No. I.

B. F. Beard's (originally Kerr's) quarry is situated in Wrightsville, at a point approximately 1,500 feet north of the Wrightsville bridge and about 300 feet west of the Susquehanna river. The quarry is one of the sidehill type and is approximately 1,000 feet long and 300 feet wide, with a clay overburden. The opening of the quarry dates back about 75 years (see H. D. Rogers, First Geol. Surv., Pa., Vol I, 1858). A siding from the "York Branch" of the Pennsylvania Railroad runs to within 100 feet of the quarry. The average dip of the limestone beds is 54° S. E., and the strike varies from N. 64° E., to N. 80° E. Types of stone in the quarry include massive, compact, white, gray and cream colored limestones, frequently containing irregularly distributed patches of dolomite; a bed of tough, compact, crystalline, gray dolomite, about seven feet in thickness; and a bed of shaly, graphitic, thinly-bedded limestone, containing an abundance of pyrite. The minerals observed are pyrite, hematite, limonite, chalcopyrite, dolomite, calcite, quartz and fluoroite.

Methods of quarrying. Stripping is done by means of pick, shovel and plow; drilling is performed by a steam drill and 40 per cent. dynamite is used for blasting, exploded by electricity. After the limestone has been broken into sizes suitable for charging into the kilns, it is loaded on small wooden cars, which are hoisted up an incline to the tops of the kilns, by a steam driven hoist, operated by a 60 H. P. boiler. There are about 60 feet of water in the older workings of the quarry and this water is kept at a certain definite level by a steam pump.

Manufacture of lime. The stone quarried is used solely for the purpose of lime-burning, although it is possible that the "seven foot bed" of dolomite will find use as road metal. The lime is used for agricultural, chemical and fluxing purposes and for making mortars and cements. Eleven "set" kilns are in use, each of which has a capacity of 1,100 bushels. The internal height of each kiln is 14 feet, and the top diameter is 12 feet, the bottom being six feet. Coal and wood are used, the former being ignited by the latter which is piled up at the base of the kiln, the coal being mixed with the limestone, as it is charged into the top of the kiln. The lime is shipped both in bulk and in barrels over the siding of the "York Branch" of the Pennsylvania Railroad to markets located throughout Pennsylvania, Mary-

land, Delaware and New York. Locally the lime is hauled from the plant in spring wagons.

Quarry No. 2.

John A. Emig's quarry is located about one mile southeast of Hellam, along the "York Branch" of the Pennsylvania Railroad, and near Creitz (Kreitz) Creek. The quarry is one of the hillside type and is approximately 90 feet long and 45 feet wide. The workings are not deep as can be seen by the weathering of the limestone, which in some instances is 25 feet or more in depth. The overburden is clay. This clay contains much iron due to the alteration and hydration of pyrite, which is common in certain beds of limestone observed in the quarry. The quarry was opened in 1909. Dip of the beds is 72° S. E., strike N. 45° E. Types of stone observed are beds of shaly pyriferous limestone; a gray, compact limestone and patches of Walcott's "Intraformational Conglomerate." The thin shaly limestone appears upon hasty examination to be unfit for purposes of lime manufacture, but upon calcining yields an exceptional grade of lime. Pyrite, quartz, calcite and dolomite are the only minerals observed.

Methods of quarrying. Stripping is done by pick and shovel; drilling by hand only; for blasting a 40 per cent. dynamite is used and is exploded by fuse. After the rock is blasted down it is further broken into sizes suitable for handling, loaded on carts and conveyed to the kiln tops. As the quarry is level, atmospheric evaporation is resorted to.

Manufacture of lime. The stone is used for the manufacture of lime which product is used for agricultural and chemical purposes, as well as for making mortars, plasters and cements. Seven "set" kilns are in use, each of which has a capacity of 1,000 bushels. Each kiln is 15 feet in height, and internal top diameter of 12 feet and a similar bottom diameter of seven feet. Three of these kilns were built in 1899-1900; two in 1908, and two in 1910-1911. Coal and wood are used, the former being mixed with the limestone and the latter to start calcination and ignite the coal. The lime is shipped to various markets over the "York Branch" of the Pennsylvania Railroad, and to local markets in spring wagons. The principal markets are situated throughout Pennsylvania, Maryland and Delaware.

Quarry No. 3.

B. H. Stoner's quarry is located about one-half mile south of the York and Wrightsville turnpike and 1¼ miles southwest of Hellam. It is about 300 feet north of the "York Branch" of the Pennsylvania Railroad. This quarry is one of the pit type, is approximately 250 feet in length and varies from 50 to 75 feet in width. It has a clay

overburden, varying in thickness from two to eight feet. The quarry was opened about 50 years ago. The observed dip of the limestone beds is 23° S. E., and the strike N. 60° E. Types of stone noted are a gray-blue, high calcium limestone; a dark-blue, shaly, pyritiferous limestone, with much graphite; a gray, banded limestone; a gray, gray-blue and cream colored limestone, containing quartz in the shape of minute rounded grains; and a blue, saccharoidal, crystalline limestone. Pyrite, sphalterite, galenite, chalcopyrite, hematite, limonite, chlorite, graphite, apatite, calcite and dolomite are observed in sparing amounts.

Methods of quarrying. Stripping is carried on by pick and shovel; drilling by a steam drill. A 40 per cent. dynamite is used for blasting, exploded by electricity. The limestone, broken into sizes suitable for charging into the kilns, is hoisted up an incline by a hoist, operated by steam generated in a 60 H. P. boiler. A spring in the quarry pit requires the almost constant use of a steam pump.

Preparing the limestone. The limestone quarried is used for the manufacture of lime, and for macadam and concrete. The limestone is hoisted to the crusher, from which it is conveyed to the screens by a chain conveyor. The screen is divided into three sections, varying in the size of the perforations from three-eights inch to 1½ inches, the intermediate size being one inch. From the screen the limestone is allowed to drop into storage-bins, from which it is withdrawn when required. The limestone is packed in bulk and shipped over the "York Branch" of the Pennsylvania Railroad to various markets located in Eastern Pennsylvania.

Manufacture of lime. The lime is used for agricultural and chemical purposes and for making cements, mortars and plasters. There are nine kilns in operation, seven of which are of the "set" type and two of the "draw" type. The seven "set" kilns were erected about 20 years ago and the two "draw" kilns, during 1907. Each kiln has a height of 18 feet. Three kilns have internal top and bottom diameters of 17 feet and 8 feet, respectively: two, have internal top and bottom diameters of 14 feet and 7 feet; two, top and bottom diameters of 8 and 5 feet, respectively; one top and bottom diameters of 12 and 6 feet; and one a top and bottom diameter of 10 and 6 feet, respectively. Five of the kilns have a capacity of 1,500 bushels each; two 400 to 500 bushels each; one 800 bushels, and one 500 bushels. The heights are taken from the top of the grate in the "set"type, whereas in the "draw" type they are taken from the base of the kiln. Pea coal, coke and wood are used for purposes of calcination, the latter to start combustion; the coal is mixed with the stone in the center of the kiln; the coke being similarly mixed with the stone around the periphery. Shipment is made over the

"York Branch" of the Pennsylvania Railroad, at Campbell's Station, to markets in various parts of Pennsylvania, Maryland, Delaware and New Jersey.

Quarry Number 4.

The quarry of the York Valley Lime Company is located along the York and Wrightsville turnpike, about 1¼ miles west of Hellam, and three-eighths mile north of the "York Branch" of the Pennsylvania Railroad. The quarry is of the pit type, 350 feet long, 85 feet wide and 65 feet deep, and was opened during the year 1899. The limestone beds are covered by a clay overburden. The dip of the beds is 45° S. E., strike, N. 72°E. Types of stone observed are massive, shaly, dark-blue; banded (a white massive stone with parallel bands of black shale); white, compact, crystalline; massive, compact, blue-gray, high calcium; gray, crystalline dolomite; dark-blue, shaly, pyritiferous and graphitic limestone, approaching a slate, in texture. Graphite, pyrite, chalcopyrite, sphalerite, calcite, dolomite, quartz, chert and fluorite are observed in sparing quantities.

Methods of quarrying. Stripping is carried on by pick, shovel and plow; drilling by means of two steam drills; a 40 per cent. dynamite is used for blasting and all charges are exploded by electricity. After the stone has been blasted down, it is loaded on steel buckets, scoop-like in appearance, these in turn are hoisted from the quarry pit by means of an overhead cable to the crusher. The stone to be used for lime burning is emptied from the buckets into cars which run from the quarry to the kilns, a distance of approximately one-quarter mile. Upon reaching the kilns, the stone is loaded from the cars onto scoops and by means of another overhead cable is charged into the tops of the kilns. Drainage is effected by five steam pumps.

Preparing the limestone. The limestone quarried is used for ballast, macadam, concrete and building purposes. As the stone comes from the quarry it is charged into a jaw crusher, operated by a 20 H. P. slide-valve engine. From the crusher it is conveyed, by means of a steel bucket conveyor, to the screens, operated by the engine operating the crusher. The perforations in the screen are of three sizes, namely: one inch, two inches and three inches. From the screens, the stone is conveyed to a storage-bin from which it can be discharged into wagons or cars run beneath the draw-gate. Another 20 H. P. slide-valve engine is used to operate the conveyors. All crushed stone is shipped in bulk form to local markets, either in wagons or over the York Branch of the Pennsylvania Railroad.

Manufacture of lime. The lime produced is used for agricultural and chemical purposes and for mortars, cements and plasters. There were twelve Keystone Patent Flame Kilns in operation at this plant,

four of which are old in design, the remaining eight being of the improved type. (On the night of March 12, 1912, the kilns were destroyed by fire. At the time of writing this report, the kilns were operating on full time, but it will be some time before operations are resumed.)

The limestone, after being properly sized was charged into the top of the kiln, and gradually moved towards the bottom, as the underlying portions were withdrawn. Heat was provided by two furnaces, situated on the opposite sides of the kiln near the base, the bottom of each furnace resting upon the floor. The finished product was allowed to fall into the cooling chamber, prior to being withdrawn. After cooling slightly, the lime was withdrawn through the bottom of the cone by opening two draw-gates, which allowed the lime to fall into cars beneath. Four of the kilns were erected in 1903; four in 1905 and four in 1907. The height of the kilns from the floor level to the top was 47 feet and 10 inches. The outside diameter of the steel shell was 11 feet, of the inside of the lining six feet six inches. The capacity of each kiln, working 24 hours, was 300 tons. Fuel was used in furnaces situated without the kiln, the heat from which was allowed to pass into the kiln through the walls which were lined with fire-clay. Either natural or forced draught was used. The finished product was shipped in bulk and in burlap bags, each holding 160 pounds, to markets all over the eastern United States, over the "York Branch" of the Pennsylvania Railroad, and locally, in spring wagons.

Quarry Number 5.

The quarry of John Schum and Geo. A. Ruhl is located along Diehl's Mill Road about 1½ miles northeast of York and one-eighth mile north of the "York Branch" of the Pennsylvania Railroad. The quarry was opened during 1899 and is one of the sidehill type, 100 feet in length and 35 feet in height and is covered by clay, the thickness of which varies from one foot to 25 feet. Owing to the abundant fracturing of the rock, it is impossible to obtain any satisfactory dip or strike, but the probable dip of the beds is 24°SE., and the strike N. 84°W. The types of stone observed are beds of blue, compact, massive limestone containing many intercalated veins of calcite; a gray, dolomitic limestone; a crystalline, coarse-grained limestone and a surficial limestone, containing beds of limonite, with malachite. Calcite, dolomite, limonite, hematite, pyrite, quartz, chalcopyrite, malachite, ankerite, siderite and nitro-calcite are observed in sparing quantities.

Methods of quarrying. Stripping is done by pick, shovel and plow, drilling by a steam drill; all blasting is done with a 40 per cent. dynamite, which is exploded by fuse. After the limestone has been blasted down it is loaded on carts and hauled to the crusher. Atmospheric exaporation is resorted to.

Preparing the limestone. The stone as it comes from the quarry is emptied into a jaw crusher, operated by a 50 H. P. motor. From the crusher, it is conveyed to the screens, the perforations of which are five-eights inch, one inch and two inches in diameter. After being screened the stone falls into a storage-bin from which it is discharged into wagons. It is sent entirely to local markets in spring wagons.

Quarry Number 6.

The quarry of H. S. Ebert and A. M. Hake is located on West Philadelphia street, about 1¼ miles east of York, and one-eighth mile south of the "York Branch" of the Pennsylvania Railroad. The quarry was opened about 30 years ago and is of the pit type, 400 feet in length, 200 feet in width and 25 feet in depth, with a clay over-burden. The dip of the beds is 55°SE., the strike, N.59°E. A thinly-bedded, shaly limestone; a gray-blue, compact limestone; and a gray limestone, with white and blue patches are the characteristic types observed. Pyrite, fluorite, calcite, dolomite, quartz and chalcopyrite are the minerals observed.

Methods of quarrying. Stripping is done by pick and shovel and drilling by hand; dynamite is used for blasting, the charges being exploded by fuse. After the rock has been quarried, it is loaded on carts and hauled to the crusher. Atmospheric evaporation is resorted to.

Preparing the limestone. The stone is charged into a jaw crusher, operated by a motor. From the crusher, it is conveyed to the screens by a bucket conveyor. The perforations in the screens are one-quarter inch, seven-eights inch and one and one-half inches, the latter representing the oversize, the stone falls into a storage-bin from which it is withdrawn and discharged into spring wagons and carts. All stone is shipped to local markets, either in spring wagons or carts.

Quarry Number 7.

Charles E. Miller's quarry is located about five-eights mile south-east of York, on the same property as C. E. Miller's Steam Brick Works, and five-eights mile southwest of the Maryland and Pennsylvania Railroads. It was opened about 50 years ago; is of the sidehill type, 220 feet long, 280 feet wide and 15 feet high with a clay over-burden. As the limestone beds are followed to the south, the thickness of the overburden becomes very great. The dip of the beds varies from 18°SE., to 72°SE., the strike, N. 77°E. Various beds of stone observed include a shaly, thinly-bedded, gray-blue and blue limestone; gray limestone containing much silica, in the form of quartz grains; and beds of gray limestone having a sharp and conchoidal fracture.

Calcite, dolomite, quartz, pyrite and chalcopyrite are sparingly present.

Methods of quarrying. Stripping is done by pick and shovel and drilling by hand; all blasting is done with black powder and fuse. After the limestone has been broken down, it is loaded on carts and drawn to the crusher, in case crushed stone is desired. If the stone is required for building purposes, it is loaded on wagons in the quarry.

Preparing the limestone. The limestone when crushed is used as ballas, macadam and for making concrete; untrimmed, it is used for building purposes. As the stone comes from the quarry, it is charged into a small crusher operated by steam. From here it is hoisted to the screens by a bucket conveyor. The material is stored in bins until further desired. It is sent to the markets, which are entirely local, by wagons or carts.

Quarry Number 8.

P. S. Burgard's quarry is located about 1¼ miles northwest of York, and seven-eighths mile west of North George street, extended. The quarry is one of the pit type and was opened about 75 years ago. Reference is made to one of the quarries on the property of P. S. Burgard as "one mile northwest of town are extensive quarries, in one occurs a beautiful flesh-colored marble." (see H. D. Rogers, First Geol. Surv., Pa., Vol. 1, p. 222, 1858). The quarry is 150 feet in length, 70 feet in width and 20 feet in height, and has a clay overburden, the thickness of which varies from two to ten feet. The dip of the beds is approximately 10°SE., and the strike N. 57°E. Among the various types of stone observed may be mentioned a white, compact marble; a pink, compact marble, with and without patches of dolomite; a rock intermediate between pisolite and oolite, with a cement consisting of a red, ferruginous clay and limestone; blue-gray white, cream and pink limestones; compact, fine-grained marbles, with patches of red, shaly, ferruginous matter, giving the marbles a mottled appearance; and a white, saccharoidial limestone. Calcite, dolomite, hematite, and quartz are the common minerals occuring in the quarry. There are numerous beds of the red clay which contain talc, serpentine and other hydrous silicates.

Methods of quarrying. Stripping is done by pick and shovel; drilling with a steam drill; both dynamite and black powder are used for blasting and are exploded by fuse. After the stone has been blasted down it is broken into sizes suitable for handling, loaded on carts and hauled to the kilns on N. George street, extended. Drainage is carried on by means of a steam pump, which is kept in continuous action, owing to a large spring in the quarry pit.

Manufacture of lime. The limestone quarried is used for lime-making, the lime, in turn being used for chemical, agricultural and build-

ing purposes. There are two "draw" kilns in operation, which have been remodeled, although the original kilns stood on the present site for more than 100 years. Each kiln is 25 feet in height and has an internal bottom diameter of eight feet and a similar top diameter of eight and one-half feet. The capacity of each kiln is 1,750 bushels. Pea coal and coke are used, the former being mixed with the stone in the centre of the kiln; the latter around the periphery. After the lime has been withdrawn from the kilns, it is packed in barrels or loose on spring wagons and carts, and taken to local markets.

Quarry Number 9.

The quarry of the Emigsville Quarry Company, owned by Cap't W. H. Lanius of York, is located near the Harrisburg-Baltimore turnpike, at Emigsville, one-quarter mile southwest of the Emigsville station along the Northern Central Railway, and four miles north of York. The quarry is one of the pit type and was opened about 60 years ago. It is 120 feet long, 80 feet wide and 35 feet deep, and is covered by clay, the thickness of which is very small. The dip of the beds is 34°SE., and the strike N. 58°E. Beds of blue-gray, saccharoidal limestone; gray, compact, tough limestone; a blue, compact, massive limestone; gray-blue saccaroidal and a gray, dolomitc limestone are observed. Among the various minerals are dolomite, calcite, quartz, fluorite, chalcopyrite, sphalerite, pyrite, asbestus and talc.

Methods of quarrying. Stripping is done by pick, shovel and plow; drilling with a steam drill. A 40 per cent. dynamite is used and all charges are exploded by electricity. After the stone has been blasted down, it is loaded on cars, which are hoisted up an incline by a hoisting-drum operated by a 30 H. P. steam engine. The stone is allowed to fall into a hopper, from which it is fed into the crusher by hand. The quarry is frequently filled with water which necessitates the use of a steam pump.

Preparing the limestone. The limestone besides being burned for lime, is used for building purposes, concrete and ballast. The limestone coming from the quarry is crushed in a jaw crusher. From the crusher the stone is conveyed by a bucket conveyor to the screens which are perforated into sizes varying from three-eighth inch to one inch. From here, the stone is stored in bins until desired. The crushed stone is shipped to local markets, by means of wagons, carts or trolley cars.

Manufacture of lime. The lime is used for building and agricultural purposes. Three "draw" kilns are in use, which are encased in a concrete shell, the spaces between the external walls of the kilns and the internal walls of the concrete shell being filled in with clay, so as to give more resiliency to the kiln. These kilns were built

during 1911, and their building caused a lack of operation in quarrying. Each kiln is 25 feet high and has an internal top diameter of seven feet and internal middle diameter of 18 feet and internal bottom diameter of 22 inches and holds 500 bushels of stone. Pea coal, stove coal and coke are used. The coal is mixed with the stone in the centre of the kiln; the coke around the periphery. Markets are entirely local, the lime being hauled in wagons and carts.

Quarry Number 10.

The quarry of the Union Stone Company, owned by the J. E. Baker Company, of York, is located about three-eights mile north of New Holland, and 800 feet west of the Susquehanna river. A siding of the "low grade" freight division of the Pennsylvania railroad runs into the yard of the plant. The quarry is one of the pit type, and was opened during 1903-1904. It is 350 feet long, 150 feet wide and varies in depth from 55 feet to 75 feet. The overburden is clay, which in some places is so thick, as to warrant abandonment of that part of the quarry. The dip in the railroad "cut" to the north approximates 30°NE., and the strike, N. 58°E., but the dip in the quarry appears to be 12°SE. Among the stones observed may be mentioned beds of blue-gray, compact, massive, limestone; blue, compact limestone with numerous patches of dolomite and veins of calcite; gray and blue dolomitic limestones. Calcite, dolomite, quartz, siderite, ankerite, aragonite, fluorite, sphalerite, graphite, pyrite, chalcopyrite, hematite and limonite are sparingly present in the limestones.

Methods of quarrying. Stripping is done by pick, shovel and plow: three steam drills are used. A 40 per cent. dynamite is used and all charges are fired by electrcity. The limestone after being broken into sizes suitable for handling, is loaded on cars, which are hoisted up an incline to the crusher by a hoisting drum, operated by a steam engine. Two steam pumps are required to raise the water to the first level; and two to pump the water from the quarry.

Preparing the limestone. The limestone quarried is used mainly for purposes of fluxing, although a little is used as macadam. As the stone comes from the quarry, it is crushed in two movable jaw crushers, operated by a steam engine. From the crushers the stone

is conveyed by means of a bucket conveyor to the screens, the perforations in which are three-quarters inch, one inch, two inches, three inches and four inches in diameter. Sometimes larger pieces are required. The screened stone is stored in bins from which it is discharged into freight cars, wagons or carts. Shipments are made over the "low grade" freight division of the Pennsylvania Railroad, to various markets in eastern United States.

Quarry No. 11.

The quarry of the York Stone and Supply Company, owned by Eli Z. Zim, Wm. Scheffer and Conrad Myers, all of York, is located along the York and Dover trolley line, 1¼ miles northwest of York, and one-half mile northwest of the West York station of the "York, Hanover and Frederick Division" of the Pennsylvania Railroad and the Western Maryland Railroad. The quarry was opened between 1899 and 1901 and is of the sidehill type, 350 feet long and 45 feet high, with a clay overburden. The dip of the beds is 16° N. W., and the strike N. 6° W., to N. 34° W. Types of stone observed are beds of dark-blue, massive, compact, limestone, containing much vein calcite and pyrite; gray-blue and gray, massive, highly fractured limestones, gray-blue massive limestone, and a bed of vein calcite, about 16 inches thick. Calcite, dolomite, fluorite, gypsum, quartz, serpentine, talc, pyrite, galenite, sphalerite, chalcopyrite, hematite, limonite and malachite are observed in sparing quantities. Some of the more common of these minerals occur in beautiful crystals.

Methods of quarrying. Stripping is done by pick and shovel; drilling, by three air-hammer drills, air for which is furnished by an air-compressor, operated by an 85 H. P. slide-valve, throttle engine; blasting is carried on by dynamite, fired by electricity. After the limestone has been blasted down, it is loaded on cars and hoisted up an incline by a hoisting drum, Drainage is brought about by atmospheric evaporation.

Preparing the limestone. The limestone is used for ballast, macadam, concrete and building purposes. As it comes from the quarry it is crushed in a gyratory crusher, the oversize from this crusher passing through a "disc" pulverizer; both crusher and pulverizer

A.

Plate XVI. N. E. wall of the Thomasville Stone and Lime Company's quarry, showing massive white limestone.

B.

N. W. wall of the quarry of the York Stone and Supply Co., showing contact between a bed of dark-blue limestone and one of gray, fractured type.

are operated by the same engine that operates the air-compressor. After the stone has been crushed it is conveyed to the screens by a bucket conveyor. It is screened into sizes of one-quarter inch, one inch, one and one-half inches and two inches. The stone used for building purposes is trimmed in the quarry. From the screens the stone is stored in bins until desired. It is conveyed to local markets, in wagons, carts, or freight cars (trolley).

Quarry No. 13.

The quarry of Hartley, Ziegler Co., owned by J. W. Hartley and Jacob Ziegler of York, and operated by L. D. and Wm. A. Cunningham, is located along the Western Maryland Railroad, two miles west of York, and one-quarter mile south of West York. The quarry is one of the pit type and was opened about 25 years ago. It is 120 feet long, 50 feet deep and 80 feet wide, and has a clay overburden, the thickness of which varies from three to twelve feet. The dip of the beds varies from 42° S. E., to 51° S. E., and the strike is N. 56° E. Among the important types of stone are beds of massive, compact blue-gray, crystalline limestone; gray-blue, massive, compact limestone; blue-gray, dolomitic limestone; and massive, blue limestone, containing much quartz in the form of grains. Dolomite, calcite, quartz, sphalerite, fluorite, galenite, nitro-calcite, talc, serpentine, pyrite, barite, malachite and an undetermined mineral, very soluble in water, are sparingly present.

Methods of quarrying. Stripping is done by pick and shovel; drilling is carried on with a steam drill. A 40 per cent. dynamite is used and all charges are fired by electricity. After the stone has been blasted down and loaded on cars, it is hoisted up an incline by a drum, operated by a 40 H. P. steam engine, steam for which is generated in an 80 H. P. boiler. Drainage is provided for by two steam pumps.

Preparing the limestone. The limestone is used for ballast and concrete. After being hoisted up the incline, the stone is charged into a gyratory crusher, from which it is conveyed by a bucket conveyor to the screens, where it is screened into sizes varying from one-half inch to four inches. From the screens the stone is stored in bins, from which it is transported to local markets, in wagons or carts.

Quarry No. 14.

The quarry of the Thomasville Stone and Lime Co., owned by J. P. Gittings, of Baltimore, Md., is located along the Western Maryland Railroad, about one-quarter mile south of Thomasville. The quarry was opened in 1900 and is one of the pit type, being 300 feet long,

300 feet wide and 77 feet deep, with a clay overburden, the thickness of which varies from one foot to six feet. There is an absence of dip, and the strike is north and south. The various beds observed include white and rose colored marbles; gray-blue, massive, compact limestone; pisolitic limestone; and white and gray-blue, crystalline limestone. Calcite, dolomite, quartz and pyrite are the minerals observed.

Methods of quarrying. Stripping is done by pick, shovel and plow and scoop; drilling is carried on by steam drills. For blasting, 20 per cent. dynamite is used and for mud-capping, a 40 per cent. dynamite. The stone is placed on skips and is drawn up an incline by two hoisting drums, operated by steam. One drum is used to hoist the stone to the kilns; the other to the crushers. During 1912-1913, a steam shovel will be installed to be used for loading the cars, prior to being hoisted to the kilns and crushers. Drainage is carried on by five steam pumps, but a bucket elevator will be installed during 1912-1913.

Preparing the limestone. The limestone is used for lime, flux, concrete, cement, etc. As it comes from the quarry, the stone is fed into a gyratory crusher, from which it is carried by a bucket conveyor to the screens, the oversize being recrushed. From the screens the limestone to be used for certain purposes is elevated to the dryer and from this, over a grizzly to another elevator, which empties the stone into a jaw crusher. From here the stone passes through a set of rolls, and the limestone to be further pulverized passes through a gyratory crusher and finally through a tube-mill. The stone is screened, both through a revolving screen and a grizzly. It is conveyed to the former by a bucket conveyor and to the latter by a bucket elevator. The crushed stone is stored in wooden bins, the pulverized material in steel bins. The stone is shipped to markets in New York, New Jersey, Pennsylvania and Maryland.

Manufacture of lime. The lime is used for cement, plaster, mortar, glass manufacture, paper manufacture, general chemical use, as a water softener, and as a fertilizer. There are 14 kilns in operation, the method of operation being similar to that of the Keystone Patent Flame Kiln, with the exception that the cooling-cone is not hung from a steel support. It is built compactly and attached directly to the kiln, acting, in a way, as the partial foundation of the kiln. Eight of the kilns were erected between the years 1900 and 1910, three in 1911 and three in 1912.

Each kiln is 45 feet in height from the bottom of the cooling-cone to the top of the charging-door. Nine of the kilns are 11 feet 6 inches and five are 9 feet 4 inches, outside diameter. Bituminous coal (slack) is used, and is burned in furnaces situated without the

A.

Plate XVII. Two levels of the quarry of Thomasville Stone and Lime Co., of Thomasville, Pa.

A.

Plate XVIII. Cross and horizontal-bedding, in the quarry of L. H. Alwine. Spring Grove, Pa. Along the tracks of the P. R. R. "York, Hanover and Frederick Division."

B.

Anticlinal folding, in L. H. Alwine's quarry. Spring Grove.

kilns. By opening draw-gates the lime falls into steel wheel-barrows. All shipments are made over the Western Maryland Railroad and other lines, to markets in New York (middle), Northern Pennsylvania, and other points in eastern United States.

Quarry No. 15.

The quarry of James March is located on the property of the Sandusky-Portland Cement Co., of York, 2½ miles west of York, 1,500 feet north of the "York, Hanover and Frederick Division" of the Pennsylvania Railroad and 750 feet south of the Western Maryland Railroad. The quarry was opened during 1911, is of the pit type and is 120 feet long, 10 feet deep and 65 feet wide, with a clay overburden. The dip is 50° S. E., and the strike N. 60° E. Beds of gray-blue, massive, saccharoidal limestone and compact, gray-blue limestone are observed. Calcite, dolomite, quartz and pyrite are sparingly present in the limestone.

Methods of quarrying. Stripping is done by pick and shovel; drilling by a steam drill; a 40 per cent. dynamite is used and all charges are fired by fuse. After the stone has been quarried it is loaded on side-dump steel cars and hoisted to the crusher by a 30 H. P. steam engine. Atmospheric evaporation is resorted to.

Preparing the limestone. The limestone is used for ballast, macadam and concrete. As it comes from the quarry it is charged into a jaw crusher, operated by the engine used to operate the hoisting-drum. From the crusher the stone is conveyed to the screens by a bucket conveyor, and is screened into sizes of one-quarter inch, one inch, two inches and three inches. The stone is then stored in bins, from which it is discharged into wagons or carts and sent to local markets.

Quarry No. 16.

L. H. Alwine's quarry is located along the "York, Hanover and Frederick Division" of the Pennsylvania Railroad, approximately one-half mile west of Spring Grove, York County. The quarry was opened in 1862, is of the sidehill type; is 300 feet in length and 28 feet in heighth, with a clay overburden. The dip varies from 5° S. E., to 8° S. E., the strike from N. 20° W., to N. and S. Types of stone observed are dark-blue and gray-blue massive, compact limestone, and beds of shaly, pyritiferous limestone. Calcite, dolomite, gypsum, quartz, fluorite, serpentine, pyrite and chalcopyrite are sparingly present.

Methods of quarrying. Stripping is done by a pick and shovel; steam drilling is resorted to. A 40 per cent. dynamite is used and all

charges are fired by fuse. The stone, after being quarried, is loaded on carts and hauled to the crusher. Drainage is brought about by atmospheric evaporation.

Preparing the limestone. The limestone is used for concrete, macadam and fertilizer. As the stone comes from the quarry it is charged into a jaw crusher, the finer material being pulverized in a pulverizer. From the crusher the stone is carried, by a bucket conveyor to the screens, in which it is sorted into sizes of one-half inch, three-quarters inch and one and one-half inch. The fine material is pulverized to sizes less than one-quarter inch and is conveyed to a chute, from which it is loaded on cars, etc. The stone (crushed to sizes larger than one-quarter inch) is stored in bins, from which it is withdrawn and loaded on freight cars, wagons or carts and hauled to local markets.

CHAPTER III.

Types of Limestone and Minerals in the York Valley Limestone Belt.

This belt is one in which many and varied types of limestone occur. With the exception of one or two cases, many quarries are not very uniform in texture, color or composition. Parts of the same bed may vary widely, but as a rule use can be made of all the limestone, either for lime or for macadamizing purposes.

Mention is made in report C., of the Second Pennsylvania Geological Survey (1876) of the following limestones:

Bastard, Auroral, Beeler's, Bull's Run, Feigley, York, Conglomerate, Saccharoidal, Dolomite, Ziegler's and Stalactitic.

Of these the conglomerate, saccharoidal, dolomite, auroral (a term comprising practically all of the limestones in this district), York and Beeler's limestone (very much related to the present "Intraformational Conglomerate" of Walcott), are the most common.

The "Intraformational Conglomerate" of Walcott is met with at many places, as in Detwiler's old quarry, North of Wrightsville; opposite the Post Office at Wrightsville; near Stoner's station along the P. R. R. York Branch, and a short distance north, in an abandoned quarry (Stoner's); in the present working quarry of J. A. Emig; and in many outcrops between Wrightsville and Hellam.

The "dolomitic" limestone of Frazer, Jr., occurs in many places, throughout the belt, as in the quarries of B. H. Stoner, York Valley Lime Co., and L. M. Palmer Lime Co.

The "saccharoidal" limestone occurs in a few places, mainly located between Wrightsville and Hellam. From the former to the latter locality, a comparatively wide body of a shaly, thinly-bedded, pyritiferous limestone, can be traced.

Walcott's "Intraformational Conglomerate" was supposed, by Frazer, Jr., to be composed of "blue (York) limestone, enveloping white (older) boulders and fragments of limestones." It was thought that there "may be two types of Auroral limestone (the York and an older one)."

Character of Observed Limestone.

1. Massive, dirty-white limestone, with much dolomite, in patches. B. F. Beard's quarry, Wrightsville.
2. Massive, blue, compact, fine-grained, graphitic, shaly, pyritiferous. B. F. Beard's quarry, Wrightsville.
3. Massive, gray, coarse-grained, crystalline dolomite. B. F. Beard's quarry, Wrightsville.
4. Massive, compact, blue limestone, with much grain quartz. Abandoned quarry of Stacey and Wilton, Wrightsville.
5. Massive, compact, fine-grained limestone. Abandoned quarry of Detwiler, S. of Creitz Creek, Wrightsville.
6. Gray, saccharoidal, dolomite. Abandoned quarry of Stacey and Wilson, Wrightsville.
7. Gray-blue, massive, limestone, with much grain quartz. Same locality as No. 6. N. wall.
8. Gray, crystalline, saccharoidal, containing patches of dolomite. Same locality as No. 6. N. wall.
9. Gray-blue, shaly, pyritiferous, with grain quartz. Same locality as No. 6. N. wall.
10. Impure, shaly, with grain quartz. Same locality as No. 6. N. wall.
11. Dark-blue, shaly, pyritiferous limestone. Same locality as No. 6. S. wall.
12. Massive, dark-blue, compact, fine-grained, limestone. Outcrop along the road from Wrightsville to Accomac.
13. Gray, compact, fine-grained limestone. Same locality as No. 12.
14. Gray-blue, compact, fine-grained limestone. Outcrop 100 feet N. of locality No. 12.
15. Dark-blue, dolomitic limestone, with patches of white, coarse-grained, crystalline dolomite. Same locality as No. 14.
16. Blue, compact, shaly, with vein calcite. Outcrop on 5th St., Wrightsville (N. of turnpike).
17. Gray-blue, ferruginous, pyritiferous and siliceous limestone. 600 feet N. of locality No. 16.
18. White, massive, compact, with black bands. 700 feet N. of locality No. 16.
19. Dark-blue, conglomeratic limestone. Near locality No. 19.
20. Gray-blue, massive, with quartz grains. Outcrop along road N. from first toll gate, West of Wrightsville.

21. Blue, compact, siliceous, with patches of white dolomite. Same locality as No. 20. Further N.

22. Compact, cream colored, crystalline dolomite. Same as locality No. 20. Further N.

23. Compact, dark-blue, siliceous, with patches of dolomite. Same locality as No. 20. Further N.

24. Compact, massive, white marble, with streaks of dolomite. Third road W. of Wrightsville and N. of the turnpike.

25. Shaly, pyritiferous limestone. J. A. Emig's quarry, Hellam.

26. Gray-blue, crystalline, saccharoidal limestone. Same locality as No. 25.

27. Gray-blue, with grain quartz. B. H. Stoner's quarry, Hellam.

28. Pale, gray-blue, crystalline limestone. Same locality as No. 27.

29. White, crystalline limestone. Same locality as No. 27.

30. Dark-blue-gray, crystalline limestone. Same locality as No. 27.

31. Very compact, tough, gray-blue limestone. Same locality as No. 27.

32. Mottled and banded limestone. Same locality as No. 27.

33. Shaly, pyritiferous limestone. Same locality as No. 27.

34. Massive, dark-blue, slightly shaly. York Valley Lime Company's quarry, Hellam.

35. Banded, wavy, black and white. Same locality as No. 34.

36. White, compact, crystalline. Same locality as No. 34.

37. Blue-gray, massive, compact. Same locality as No. 34.

38. White, saccharoidal limestone. Same locality as No. 34.

39. Dark-blue, compact, massive, pyritiferous. 2½ miles N. E. of York. On the Vinegar Ferry Road.

40. White, saccharoidal, with patches of gray dolomite. Schum and Ruhl's quarry. York.

41. Surficial, copper-bearing, porous, brown to yellow, with vein of iron ore. Same locality as No. 40.

42. Cream, massive, coarse-grained dolomite. Ebert's Lane, near the P. R. R., York Branch, E. York.

43. Gray-blue, massive, compact, crystalline. Ebert and Hake's quarry, York.

44. Massive, blue limestone, breaking with a conchoidal fracture. Same locality as No. 43.

45. Blue, shaly, massive, compact, with grain quartz. Abandoned quarry of J. H. Longstreet, York.

46. Gray-blue, compact, with grain quartz. C. E. Miller's quarry, York.

47. Gray-blue, shaly, pyritiferous, with vein calcite. Same locality as No. 46.

48. White, compact marble. P. S. Burgard's quarries, York, R. F. D. No. 10.

49. Pink, compact marble, with some dolomite filling. Same locality as No. 48.

50. Pisolitic limestone set in a base of red, shaly clay. Same locality as No. 48.

51. Fine-grained, compact, saccharoidal, with patches of dolomite. Same locality as No. 48.

52. Compact, fine-grained, marble, with patches or red clay and dolomite. Same locality as No. 48.

53. Compact, oolitic, massive, gray in color. Same locality as No. 48.

54. Massive, compact, white limestone. Same locality as No. 48.

55. Massive, compact, gray limestone. Same locality as No. 48.

56. White, massive, saccharoidal, showing contact with red clay. Same locality as No. 48.

57. Shaly, alternate bands of calcite and dolomite. Emigsville Quarry Company, quarry, Emigsville.

58. Massive, compact, blue-gray, saccharoidal limestone. Same locality as No. 57.

59. Massive, compact, shaly limestone. Same locality as No. 57.

60. Massive, gray, crystalline, with fluorite and dolomite. Same locality as No. 57.

61. Blue, graphitic, alternating light and dark-blue. Union Stone Company's quarry, New Holland, York County.

62. Massive, compact, blue limestone. Same locality as No. 61.

63. Dark-blue, compact, shaly, pyritiferous. 2½ miles S. E. of Emigsville. On Rudy's Mill Road.

64. Dark, gray-blue, massive, compact, very pure, limestone. Rudy's quarry, 2½ miles S. E. of Emigsville.

65. Brown, shaly, siliceous, pyritferous limestone, schistose. Milk Factory Road, near N. George St., Ext., York.

66. Gray, dolomitic limestone. Outcrop on road leading from the Board Road to the Bull Road.

67. Gray, pisolitic dolomite. Same locality as No. 66.

68. Gray, compact, tough, crystalline limestone. York Stone and Supply Company's quarry, York.

69. Massive, gray, tough, compact, fractured limestone. Same locality as No. 68.

70. Very fine-grained, dark-blue limestone, with fluorite and vein calcite. Same locality as No. 68.

71. White, compact, fine-grained limestone, L. M. Palmer Company's quarry, Smyser's Station, York.

72. Gray, massive dolomite. Same locality as No. 71.

73. Fine-grained, massive, compact, blue limestone. Same locality as No. 71.

74. White, and blue, massive, compact limestone, with dolomite patches. Same locality as No. 71.

75. Massive, compact, dark-blue, limestone. Emits a metallic sound when struck. Cunningham's quarry, W. York.

76. Compact, massive, gray, mottled limestone. Same locality as No. 75.

77. Massive, gray, crystalline limestone. Same locality as No. 75.

78. Massive, blue-gray limestone. Same locality as No. 75.

79. Massive, pure-white, compact, crystalline limestone. Same locality as No. 75.

80. Massive, pure-white, and crystalline limestone. Thomasville Stone and Lime Company's quarry, Thomasville.

81. Massive, compact, pale rose marble. Same locality as No. 80.

82. Massive, gray-blue, compact, crystalline limestone. Same locality as No. 80.

83. Massive, pisolitic, gray, compact. Same locality as No. 80.

84. Massive, gray-blue limestone. Same locality as No. 80.

85. Compact, dirty-white, dolomitic limestone. At contact between limestone and shale. 3½ miles W. of York. 400 feet S. of Bricklyn Sta., W. M. R. R.

86. Compact, banded gray and blue-gray, pyritiferous. Contact with the Stony Brook dike.

87. Conglomeratic, gray and blue patches, some shaly. Abandoned quarry of E. Stoner, near Stoner's Sta.

88. Compact, gray, fractured dolomite. W. M. R. R. "cut" near Bricklyn.

89. Compact, gray, fractured, dolomitic and high calcium. Intersection of Bull Road and Foust-town Road, 3½ miles N. of York.

90. Gray, compact, high calcium limestone. W. M. R. R. "cut" 1,700 feet S. of Thomasville Stone and Lime Co.

91. Gray-blue, compact, high calcium limestone. 2 miles N. W. of Hanover.

MINERALS OBSERVED IN LIMESTONES.

Many minerals are found in the York Valley Limestone Belt which are identical with most of those found in other sedimentary deposits of limestone. The minerals here described have been observed in and collected from the quarries operated at the present time.

NATIVE ELEMENT.

Graphite, C.

Impure carbon. This mineral has frequently been observed in limestone that show a high pyrite and silica-bearing content. It occurs (a) as a very thin film, possessing the characteristic blackish, lead-gray color, metallic lustre and greasy and unctuous feel to the

touch. Upon being drawn over a sheet of white paper, the black streak remains.

Graphitic carbon (b) has also been found in many of the dark-blue limestones. This can be seen by dissolving the limestone in dilute hydrochloric acid, when a black scum will be seen to float upon the surface of the liquid. Upon further treatment, this scum is found to be graphitic carbon.

Variety (a) is found chiefly in the quarries of B. H. Stoner and the York Valley Lime Company.

Variety (b) is common in the quarries of the York Valley Lime Company, York Stone and Supply Company, and Cunningham Brothers.

SULPHIDES.

Galena PbS.

As is invariably the case in all sedimentary limestone deposits, this mineral is found sparingly throughout the district. No crystals have been observed, but numerous cleavage fragments encrusting minute cavities in the limestone, are of common occurrence.

Galena is a sulphide of lead; when pure, is composed of 86.6 per cent. of lead and 13.4 per cent. sulphur. It is very heavy, possesses a lead-gray color and streak and when it is struck by a hammer, breaks into cubes, showing its characteristic cubic cleavage. It is soft, but harder than the limestone. It occurs in the quarries of the York Valley Lime Company, L. M. Palmer Lime Co., and the York Stone and Supply Company.

Sphalerite. ZnS.

Associated with galena, is the sulphide of zinc or sphalerite, containing, when pure, 67 per cent. of zinc and 33 per cent. of sulphur. Locally, this mineral varies in color from a pale lemon-yellow to a deep brown, almost blackish-brown. It occurs in cleavage fragments only, and is about as hard as galena. A distinguishing feature is its resinous lustre.

Thus far the mineral has been found in the following quarries: B. H. Stoner, York Valley Lime Company, Emigsville Quarry Company, Union Stone Company, York Stone and Supply Company, L. M. Palmer Lime Co., and Cunningham Brothers.

Chalcopyrite. $CuFeS_2$.

Minute tetrahedral crystals of chalcopyrite have been observed and are especially noticeable in certain quarries. They occur as tetrahedra forming interior cores of calcite crystals; or scattered throughout veins of crystalline calcite, associated with pyrite, fluorite, hematite and quartz.

The color of chalcopyrite is brass-yellow, invariably tarnishing to an iridescent bluish-bronze color. Found in the following quarries: Beard, Stoner, York Valley Lime Company, Ebert, Miller, Schum, Emigsville Quarry Company, Union Stone Company, York Stone and Supply Company, L. M. Palmer, Cunningham Brothers and Alwine.

Pyrite. FeS_2.

Possesses a bright-yellow color, with a metallic lustre. Its powder is greenish brass-yellow in color. When struck by a hammer, pyrite emits the odor of sulphur dioxide. When pure it contains 46.6 per cent of iron and 53.4 per cent. of sulphur. Usually occurs as minute striated cubes, pentagonal dodecahedrons, or combinations of these with other forms. Sometimes the cubes are perfectly formed; again they are flattened, elongated and curved. Pyrite is fairly hard, and, when heated to a red heat, burns by the combustion of the sulphur present in the mineral. Often occurs, altered to limonite (limonite pseuomorphs after pyrite). Many calcite crystals contain inclusions of pyrite. The elongated, curved and flattened crystals are abundant in the quarry of J. H. Longstreet. Pyrite occurs in every quarry visited.

Marcasite. FeS_2.

Similar to pyrite, but crystallizing in the orthorhombic system. Occurs (?) as minute crystals, included in calcite crystals, at the L. M. Palmer Lime Company's quarry.

HALOIDS.

Fluorite. CaF_2.

Fluorite or fluospar, is a common associate of calcite and dolomite in many quarries throughout this district. It is a fluoride of calcium and varies in color from white to deep purple, with various shades of yellow, red, violet and green. Locally, the color is invariably violet or purple. No distinct crystals have been found, the most of the specimens showing cleavage only. At one quarry numerous imperfectly-formed cubes, modified by other cubes, were found, the faces of each cube being striated.

This mineral has been found in the following quarries: B. F. Beard, York Valley Lime Company; Ebert & Hake, Emigsville Quarry Company; Union Lime Company; York Stone & Supply Company; L. M. Palmer Lime Company; Cunningham Brothers and Alwine.

OXIDES.

Quartz. SiO_2.

An oxide of silicon and a mineral common to all of the local quarries. Found in the form of small grains, or in simple and modified crystals of hexagonal habit. Grain quartz is primary while the secondary quartz is represented by the crystals. (See petrographic tests, under Chapter 4). Quartz is sufficiently hard to scratch steel, but is a trifle lighter in weight than limestone. It is often colorless and transparent. The presence of quartz can readily be determined by dissolving the limestone in dilute hydrochloric acid.

Found in every quarry in the district.

Hematite. Fe_2O_3.

The red, anhydrous oxide of iron, containing 70 per cent. of iron and 30 per cent. of oxygen when pure. Usually occurs as a red incrustation on calcite crystals; as a red stain on limestone, and filling small vugs or cavities in the limestone. Hematite is distinguished by its red color and streak (powder).

It has been observed in the quarries of B. F. Beard, B. H. Stoner, Schum and Ruhl, Burgard, Union Stone Company, York Stone & Supply Company and L. M. Palmer Lime Company.

Limonite. $2Fe_2O_33H_2O$.

This is the hydrated oxide of iron, brown in color and streak. Upon heating a fragment of the mineral in a test tube, water will condense, showing that water of constitution is present. Limonite is very widely distributed (the brown stain on all rocks being an alteration product of pyrite. It occurs as a stain on the limestone, in veins and as pseudomorphs after pyrite. Much of the limestone observed in the quarries is the result of superficial alteration and in one case a 1½ inch thick surface-vein, a few feet in length, was observed. Malachite accompanied the limonite. This vein occurs in the quarry of Schum and Ruhl. In all other quarries limonite occurs as a stain or as pyrite-pseudomorphs.

CARBONATES.

Calcite. $CaCO_3$.

The most widely distributed mineral in the local quarries, containing, when pure, 56 per cent. of lime and 44 per cent. of carbon dioxide; found in crystalline and massive cleavage forms. About 125 different crystal forms have been found, some of these being of great beauty and complexity in outline.

Iceland spar (clear, flawless, transparent calcite) occurs in a few quarries. Other common colors are brown, yellow and gray. Some of the calcite specimens are banded (alternate brown and gray); some black and red bands (corbonaceous and ferruginous matter) and others clouded. Many crystals contain inclusions of pyrite, marcasite, chalcopyrite and malachite. Under a lens, very minute pyrite crystals can be seen to lie in the same plane as the crystallographic axes. Calcite is pure carbonate of lime and is soft, easily scratched by a knife-blade; has a white streak and a rhombohedral cleavage, breaking into rhombs upon being struck a blow with some hard object.

The commonest types of crystalline calcite are known as "dog-tooth" spar and "nail-head" a spar, but there are many modifications of these as well as other types. Twin crystals are very common.

Fine calcite crystals are to be found in the following quarries: twin crystals in the quarries of Schum and Ruhl, Union Stone Company, L. M. Palmer Lime Company and York Stone & Supply Company, other types are found in the quarries of C. E. Miller, Emigsville Quarry Company, Thomasville Stone & Lime Company, Alwine, Cunningham Brothers.

Dolomite. (CaMg) CO_3.

Commonly associated with calcite and is a double carbonate of magnesia and lime, occuring as curved rhombohedra or, locally as "saddle-shaped" crystals. Many magnificent groups of these crystals have been found and they are usually white or cream colored. Ocassionally pink cleavage specimens are observed. Dolomite is a trifle harder than calcite and its most distinctive feature is its insolubility in cold hydrochloric acid (calcite being soluble). When in massive form it can readily distinguished by its usual coarse-grained, curved cleavage plates. Massive dolomite is heavier than calcite.

"Saddle-shaped" crystals have been observed in two quarries only, viz: The York Stone & Supply Co. and Cunningham's quarry, in both instances associated with dark-blue limestones. Curved rhombs are common in the following quarries: Beard, York Valley Lime Company, Emigsville Quarry Company, York Stone & Supply Company, L. M. Palmer Lime Company, Cunningham Brothers, Thomasville Stone & Lime Co. and Alwine.

Ankerite. (Ca, Mg, Fe, Mn) CO_3.

A dark brown mineral, crystallizing in curved rhombohedra, similar to dolomite. Occurs in two quarries, Schum and Ruhl and Union Stone Company.

Siderite. $FeCO_3$.

A brown mineral with rhombohedral cleavage and similar to calcite. Occurs in the quarries of Schum and Ruhl and Union Stone Company.

Aragonite. $CaCO_3$.

Similar to calcite in composition, but crystallizes in the orthorhombic system. Occurs as white, elongated cleavage fragments in the Union Stone Company's quarry.

Malachite. $2CuCO_3Cu\ (OH)_2$.

The green hydrated oxide and carbonate of copper. Occurs as minute crystals; in cavities in a limonite vein in the quarry of Schum and Ruhl; and as tufts (alteration of chalcopyrite) in the quarries of the York Stone & Supply Company, L. M. Palmer Lime Company and Cunningham Brothers.

SILICATES.

Asbestus $CaMg_3Si_4O_{12}$.

The amphibole variety of asbestus has been found as minute fibres on the slickensided surface of limestone in the quarry of the Emigsville Quarry Company.

Chlorite. $H_{40}(Fe_1Mg)_{23}\ Al_{14}Si_{13}O_{90}$.

Occurs as an alteration product in regions of metamorphic activity. Observed in many quarries.

Serpentine. $H_4Mg_3Si_2O_9$.

Accompanying high magnesian limestones. The result of metomorphic activity. Green to brown in color. Often occurs on the slickensided surfaces of the limestone. Found in many quarries, especially abundant in the quarry of the York Stone & Supply Company.

Talc. $H_2Mg_3Si_4O_{12}$.

Of rarer occurence than serpentine. Gray to green in color. Greasy lustre and unstuous to the touch. Observed in the quarry of the York Stone & Supply Company.

NITRATES.

Nitro-calcite Ca $(NO_3)_2$.

Occurs as an incrustation of limestone, at the mouth of cavernous fissures. Observed in the quarries of Schum and Ruhl and Cunningham Brothers.

SULPHATES.

Barite. $BaSO_4$.

Occurs in orthorhombic crystals of varied modifications. The color varies from wine-yellow to deep orange-brown. It is known as "heavy spar" owing to its high specific gravity. A few beautiful clusters or rosette-like groups of crystals were collected at the quarry of the L. M. Palmer Lime Company. Some broken fragments of crystals, wine-yellow in color, were also found here. Doubly terminated crystals of barite, transparent and lemon-yellow in color, were collected at the quarry of Cunningham Brothers.

Gypsum. $CaSO_4 2H_2O$.

Gypsum is the hydrous sulphate of lime, sparingly present in this district. It occurs at two quarries, the York Stone and Supply Company and Alwine's. It has not been found locally in crystalline form but only as cleavage fragments, colorless and very soft. It has a perfect lustre which is a distinguishing characteristic. When heated in a closed tube, it evolves its water of crystallization and is converted into a white powder, known as "plaster of Paris" or "dead burned" gypsum.

CHAPTER IV.

Chemical Analyses, Physical and Petrographical Tests.

This chapter includes chemical analyses of limestones, limes and a hydrate; petrographical and road tests on limestones, and petrographical tests on "trap." A chemical analysis was made of each economically important limestone quarried, as well as each lime and a hydrate resulting from the limestone. The analyses were made under the direction of Professor Alexander Silverman, in the Chemical Laboratories of the University of Pittsburgh. Other analyses are tabulated for comparison.

Petrographic characters of limestone and "trap" were determined by the writer under direction of Mr. H. N. Eaton, Instructor in petrography in the Petrographical Laboratory of the University of Pittsburgh.

All road tests were made by Mr. L. W. Page of the Bureau of Public Roads, U. S. Department of Agriculture, Washington, D. C.

Microscopic sections were made by W. Harold Tomlinson of Swarthmore, Pa.

For convenience, the quarries, the location of each and the products manufactured at the quarries and their associated plants are shown in the following table:

No.	Product.	Name of Quarry or Plant.	Location.
1.	Lime,	B. Frank Beard,	Wrightsville.
2.	Lime,	John A. Emig,	Hellam.
3.	Lime, limestone,	Benjamin H. Stoner,	Hellam.
4.	Lime, limestone,	York Valley Lime Co.,	Hellam.
5.	Limestone,	John Schum and Geo. A. Ruhl,	York.
6.	Limestone,	H. S. Ebert and A. M. Hake,	York.
7.	Limestone,	Chas. E. Miller,	York.
8.	Lime,	P. S. Burgard (C. E. Kottcamp),	York, R. F. D.
9.	Lime, limestone,	Emigsville Quary Co.,	Emigsville.
10.	Limestone,	Union Stone Co.,	New Holland.
11.	Limestone,	York Stone and Supply Co.,	York.
12.	Lime, limestone,	L. M. Palmer Lime Co.,	Smyser's Station.
13.	Limestone,	L. D. and W. A. Cunningham,	Smyser's Station.
14.	Lime, limestone,	Thomasville Stone and Lime Co.,	Thomasville.
15.	Limestone,	James March,	Smyser's Station.
16.	Limestone,	L. H. Alwine,	Spring Grove.

Method of Analysis.

The method of analysis employed in the "Portland Cement Industry" and compiled from a paper, entitled "Method Suggested for the Analysis of Limestone, Raw Mixtures and Portland Cements, by the Committee on Uniformity in Technical Analysis, with the advice of W. F. Hillebrand," was used.

The following atomic weights were used as published in the Journal of the American Chemical Society, November, 1911:

Aluminum, ...27.1
Calcium, ...40.07
Carbon, ...12.00
Hydrogen, ... 1.008
Iron, ...55.84
Magnesium, ...24.32
Oxygen, ...16.00
Phosphorous, ...31.04
Silicon, ...28.30

Solution.

One-half gram, all of which passed through a 100 mesh sieve, was strongly ignited in a platinum crucible for 15 minutes. It was then transferred to a porcelain evaporating dish, moistened with water and 10 cc. conc. HCl (or a mixture of 10cc. water and 10cc. HCl. The moistened mass was then digested at a gentle heat and finally evaporated to dryness on an air-bath.

SiO_2.

The residue was treated with 10cc. of a mixture of water and HCl (1:1); the dish was covered and the solution digested on the bath for

10 minutes. After this the solution was filtered and the precipitate thoroughly washed with water. The filtrate was re-evaporated and dried, moistened with 10cc. (1:1) of a mixture of water and HCl, and again filtered. Both precipitates were added, placed in a weighed platinum crucible, dried, the paper burned off in a Bunsen-burner flame, and finally blasted for 15 minutes, weighed again, blasted for 10 minutes, weighed and checked.

Al_2O_3 and Fe_2O_3.

Alumina and iron oxide were not determined separately.

The filtrate was made alkaline with NH_4OH, after adding 10cc. conc. HCl. It was then boiled to expel the excess of NH_4OH and allowed to settle, washed once by decantation and slightly so on the filter. Setting aside the filtrate, the precipitate was dissolved in hot, dilute (1:1) HCl and the solution passed into the beaker in which the precipitation was made. NH_4OH was added, the solution boiled, and the precipitate collected on the same filter. Then the precipitate and filter were placed in a weighed platinum crucible, the paper burned off, ignited and blasted for 5 minutes (with care to prevent reduction), cooled and weighed as Al_2O_3 and Fe_2O_3.

CaO

A few drops of NH_4OH were added to the filtrate, which was then boiled. To the boiling solution, was added 20cc. of a saturated solution of $(NH)_2C_2O_4$. The solution was boiled until the CaC_2O_4 assumed a well-defined granular form. This was allowed to settle for 20 minutes, filtered and washed, then placed in a platinum crucible, the paper burned with a Bunsen-burner flame. The precipitate was ignited, redissolved in HCl, diluted to 100cc with water; to it was added a slight excess of NH_4OH, after which it was boiled and then reprecipitated by 20cc. $(NH)_2C_2O_4$, allowed to stand, settle, then filtered and washed. It was then ignited and blasted and weighed as CaO.

MgO.

The filtrate was acidified with HCl and boiled, then concentrated to 150cc. To it was added, 10cc. of a saturated solution of Na $(NH)_4$ $_2$H.PO_4, and the solution was boiled for 10 minutes and cooled with cold water. To it was added, drop by drop, NH_4OH with constant stirring, until the precipitate formed and then an excess of NH_4OH. The precipitate was stirred for several minutes and allowed to set for 12 hours in a cool atmosphere, and filtered. The precipitate was filtered, ignited, cooled and weighed as $Mg_2P_2O_7$.

Factors.

Factors.	
CaO in $CaCO_3$,	56.03 %
CO in $CaCO_3$,	43.97 %
MgO in $MgCO_3$,	47.818%
CO in $MgCO_3$,	52.181%
MgO in $Mg_2P_2O_7$,	36.206%
Fe in Fe_2O_3,	69.939%

Note:—Chemical analyses of many of the limestones in this district show a residue remaining upon dissolving limestone in hydrochloric acid, which residue is composed chiefly of silica, with aluminum silicates, magnesium silicates, and iron silicates. In many instances, however, a black scum floats upon the surface of the solution, which, upon being filtered off and ignited, is almost wholly volatile, proving it to be graphitic carbon, possibly resulting from animal remains, but more likely from metamorphic action, this limestone occurring in regions of metamorphic activity.

Chemical Analyses of the Limestones Quarried.

Quarry No. 1. B. Frank Beard, Wrightsville.

	1 (a)	2 (b)	3 (c)	4 (a)	5 (b)	6 (c)
$CaCO_3$,	95.29	94.53	65.14	97.10	93.82	92.21
$MgCO_3$,		3.18	32.74		3.32	7.10
Al_2O_3,		1.80	0.44		3.10	0.28
Fe_2O_3,						
MgO,	0.92			0.64		
Insol.,	0.43	0.49		0.32	0.26	
Ign.,			1.52			
SiO_2,			0.14			0.20
Total,	96.64	100.00	99.98	98.06	100.00	99.79

1, 2.—White limestone, massive compact and fine-grained.
3.—Gray dolomite, tough, massive, coarse-grained.
4, 5, 6.—Gray limestone, massive, compact and fine-grained.
(a) M. S. McDowell, analyst, State College, Pa., 1896.
(b) H. J. Patterson, analyst, State Chemist of Md., College Park, Md.
(c) M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 2. John A. Emig, Hellam.

	1 (a)	2 (b)
$CaCO_3$,	97.53	97.16
$MgCO_3$,	0.94	2.86
Al_2O_3,	0.18	0.24
Fe_2O_3,		
Insol.,	0.68	
SiO_2,		0.25
Total,	99.33	100.51

1, 2.—Gray limestone, massive, compact, medium-grained.
(a) Name of analyst not given.
(b) M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 3. Benjamin H. Stoner, Hellam.

	1 (a)	2 (a)	3 (a)	4 (b)	5 (b)	6 (b)
$CaCO_3$	99.22	98.53	63.90	96.84	95.85	95.41
$MgCO_3$	0.35	0.22	33.00	2.77	3.14	4.30
Al_2O_3,	0.24	0.55	0.54	0.54	0.16	0.22
Fe_2O_3,						
S,						
SiO_2,	0.19	0.50	2.08	0.10	0.18	0.28
Insol,	(c) tr	(c)0.20	(c)0.43			
Ign.,					(d)0.97	
Total,	100.00	100.00	100.00	100.35	99.90	100.21

1.—"Good stone"—gray-blue, massive, compact, crystalline.
2.—"Top rock"—blue-gray, massive, compact, crystalline.
3.—"Black"—blue-black, massive, shaly, high in magnesia iron and silica.
4.—"Blue stone from the surface, coarsely crystalline.
5.—"Gray No. 1"—gray, massive, compact, crystalline.
6.—"Gray No. 2"—gray, massive, compact, crystalline.
a. C. H. Ehrenfeld, Ph. D., analyst, 2-11-'08. York.
b. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.
c. Insoluble here, includes combustible matter.
d. Ignition includes water ("quarry water").

Quarry No. 4. York Valley Lime Co., Hellam.

	1 (a)	2 (b)	3 (c)	4 (d)	5 (e)	6 (e)	7 (e)	8 (e)
$CaCO_3$	98.07	97.67	98.00	89.72	98.48	84.70	95.41	95.81
$MgCO_3$,	1.41	1.72	1.51	4.60	0.32	12.64	1.82	2.54
Al_2O_3,	0.15	0.16	0.05	1.57	0.56	1.12	1.88	0.28
Fe_2O_3,				0.56				
SiO_2	0.23	0.23	0.37	1.58	0.62	1.86	0.62	1.88
FeO,								
Na_2O,				0.88				
K_2O,				0.53				
P_2O_5,				0.27				
SO_3,				0.20				
H_2O (110°C.),				0.22				
H_2O (ab. 110 C.),				4.26				
Insol,								
Total,	99.86	99.78	99.93	99.91	99.98	100.32	99.73	100.51

1, 2, 3.—Sample taken from the entire quarry.
4. —Sample taken from the entire quarry in 1910.
5. —White limestone, massive, compact, saccharoidal, fine-grained.
6. —Gray-blue limestone, massive, compact, fine-grained.
7. —Blue limestone, massive, compact, contains carbonaceous matter.
8. —Samples taken from the entire quarry in 1911.
a. Westmoreland Coal Co., analyst, Philadelphia.
b. C. H. Ehrenfeld, Ph. D., analyst, York.
c. Maryland Steel Co., analyst, Sparrow's Point, Md.
d. H. C. Demming, analyst, Harrisburg, 7-25 10.
e. M. I. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 5. John Schum and Geo. A. Ruhl, York.

	1 (a)
$CaCO_3$,	87.09
$MgCO_3$,	9.89
Al_2O_3,	0.96
Fe_2O_3,	
SiO_2,	0.88
Total,	98.82

1. Sample taken from the entire quarry, 1911.
a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 6. H. S. Ebert and A. M. Hake, York.

	1 (a)	2 (a)
$CaCO_3$,	92.59	98.37
$MgCO_3$,	3.77	0.47
Al_2O_3,	2.04	1.22
Fe_2O_3,		
SiO_2,	1.78	0.16
Total,	100.18	100.22

1. Sample taken from the entire quary, 1911.
2. Gray-blue limestone, massive, compact, crystalline.
a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 7. Chas. E. Miller, York.

	1 (a)
$CaCO_3$,	87.63
$MgCO_3$,	3.94
Al_2O_3,	1.94
Fe_2O_3,	
SiO_2,	6.04
Total,	99.55

1. Sample taken from the entire quarry in 1912.
a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 8. P. S. Burgard, R. F. D. No. 10, York.

	1 (a)	2 (b)	3 (b)
$CaCO_3$,	99.34	98.79	98.44
$MgCO_3$,	0.21	0.18	0.72
Al_2O_3,	0.18	0.80	0.36
Fe_2O_3,	0.02		
SiO_2,	0.32	0.16	0.32
P_2O_5,	0.03		
Na_2O,	0.05		
H_2O (110°C.),	0.09		
Total,	100.24	99.93	99.84

1, 2.—White limestone, massive, compact, crystalline.
3. —Gray limestone, massive, compact.
a. H. C. Demming, analyst, Harrisburg, 3-15-1908.
b. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 9. Emigsville Quarry Co., Emigsville.

	1 (a)	2 (b)	3 (c)	4 (c)
$CaCO_3$,	98.35	96.35	98.09	88.70
$MgCO_3$,	1.41	2.08	1.25	9.75
Al_2O_3,	0.13	0.15	0.40	0.76
Fe_2O_3,				
SiO_2,	0.19	1.13	0.24	0.74
$Ca_3(PO_4)_2$,		0.05		
$KAlSi_3O_8$,				
Organic Mat.,	tr.			
Total,	100.08	99.92	99.98	99.95

1, 2.—Samples taken from the entire quarry and outcrops to the north and south, 1910.
3. —Gray-blue, massive, compact, saccharoidal limestone.
4. —Sample taken from the quarry and an outcrop to the north, 1911.
a. C. H. Ehrenfeld, Ph. D., analyst, York.
b. C. A. Jacobson, Ph. D., analyst, York.
c. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 10. Union Stone Co., New Holland, York County.

	1 (a)	2 (b)
$CaCO_3$,	96.00	92.84
$MgCO_3$,	2.60	6.74
Al_2O_3,	0.20	0.18
Fe_2O_3,		
SiO_2,	1.20	0.28
Total,	100.00	100.04

1, 2.—Samples taken from the entire quarry, 1911.
a. Name of analyst not given.
b. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh.

Quarry No. 11. York Stone and Supply Co., York.

	1 (a)	2 (a)
$CaCO_3$,	65.32	87.09
$MgCO_3$,	31.23	9.32
Al_2O_3,	1.70	1.32
Fe_2O_3,		
SiO_2,	1.74	2.36
Total,	99.99	100.09

1.—Gray, compact, fractured, much metomorphosed limestone.
2.—Dark-blue, limestone, compact, massive.
a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912

Quarry No. 12. L. M. Palmer Lime Co., York (Smyser's Sta.).

	1 (a)	2 (b)	3 (a)	4 (b)	5 (a)	6 (b)	7 (c)
$CaCO_3$,		99.32		99.52		99.07	
CaO,	55.56		55.29		48.40		45.77
$MgCO_3$,		0.24		0.16		0.38	
MgO,	0.35		0.48		6.18		8.81
Al_2O_3,	0.04	0.04	0.02	0.16	0.07	0.32	0.03
Fe_2O_3,	0.05		0.10		0.30		0.27
SiO_2,	0.53	0.28	0.14	0.20	0.27	0.24	0.25
Total,	55.53	99.98	56.03	100.04	55.22	100.01	55.13
By difference,	43.47		43.97		44.78		44.87
	100.00		100.00		100.00		100.00

1, 2.—White, compact, high-calcium limestone.
3, 4.—Blue, compact, fine-grained, high calcium limestone.
5, 6.—Mottled "calico," fine-grained limestone with patches of dolomite.
7. —Average of entire quarry.
a. Analyses made during 1909, by U. S. Geol. Surv., Pittsburgh.
b. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.
c. Analysis made during 1911, by the Bureau of Standards, Pittsburgh.

Quarry No. 13. L. D. and Wm. A. Cunningham, York, (Smyser's Station).

	1 (a)	2 (a)
$CaCO_3$,	73.60	51.12
$MgCO_3$,	20.90	33.06
Al_2O_3,	1.44	3.80
Fe_2O_3,		
SiO_2,	4.00	12.00
Total,	99.94	99.98

1.—Gray-blue limestone, massive, compact.
2.—Dark blue limestone, massive, compact, containing much carboneceous matter.
a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 14. Thomasville Stone and Lime Co., Thomasville.

	1 (a)	2 (a)	3 (a)	4 (b)
$CaCO_3$,	99.35	99.48	99.29	55.45
$MgCO_3$,	0.24	0.12	0.34	0.27
Al_2O_3,	0.30	0.18	0.10	0.10
Fe_2O_3,				0.15
SiO_2,	0.22	0.40	0.22	0.15
Total,	100.11	100.18	99.95	56.12
Difference,				43.88
Total,				100.00

1.—White limestone, massive, compact, fine-grained.
2.—Gray limestone, massive, compact, fine-grained.
3.—Gray-blue limestone, massive, compact, fine-grained.
4.—Sample taken from entire quarry, 1909.
a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.
b. Analysis made in 1909 by the U. S. Geol. Surv., Pittsburgh.

Quarry No. 15. James March, York.

	1 (a)
$CaCO_3$,	86.35
$MgCO_3$,	8.94
Al_2O_3,	1.98
Fe_2O_3,	
SiO_2,	2.44
Total,	99.71

1.—Sample taken from the entire quarry.
a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Quarry No. 16. L. H. Alwine, Spring Grove.

	1 (a)
$CaCO_3$,	70.74
$MgCO_3$,	15.21
Al_2O_3,	4.04
Fe_2O_3,	
SiO_2,	9.92
Total,	99.91

1.—Sample taken from the entire quarry in 1911.
a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.

Chemical Analyses of Various Limes (a).

No. of Quarry.	CaO.	MgO.	(Fe,Al)2O$_3$.	Insol.	$H_2O_3CO_2$.	Total.
2,	93.81	3.82	0.15	0.23	1.42	99.43
2,	79.64	4.27	6.64	5.93	2.18	98.66
3,	94.04	2.04	0.54	0.38	2.07	99.07
4,	88.03	6.21	0.94	2.61	1.12	98.91
8,	96.42	1.34	0.71	0.49	0.17	99.18
9,	83.09	10.72	0.76	0.70	3.80	99.07
12 (b),	97.32	0.61	tr.	0.50	0.58	99.01
12 (c),	76.05	21.12	0.87	0.36	0.36	98.76
14,	98.54	0.49	0.00	0.01	0.72	99.76

a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.
b. High calcium lime.
c. High magnesian lime.
NOTE:—Each sample of lime was blasted for 10 minutes, cooled and weighed. The loss in weight was due to the expulsion of any carbon dioxide, moisture, etc. (volatile matter), which may have been present in the lime. The analyses were carried on as described under "chemical analyses of the various limestones quarried."

Chemical Analyses of L. M. Palmer's "Challenge Brand" Hydrate.

	(a)	Ultimate Analyses.	(b)	Proximate Analysis.
CaO,	72.94	71.66	$Ca(OH)_2$	91.67
MgO,	0.71	0.36	$CaCO_3$	4.09
Fe_2O_3,	0.40	0.51	Mg $(OH)_2$	0.70
Al_2O_3,		0.50	H_2O	1.17
SiO_2,	0.40	0.95		
CO_2,	2.16	1.80		
H_2O,	22.61	23.81		
Total,	99.22	99.59	Total,	97.63

a. M. L. Jandorf, analyst, Univ. of Pittsburgh, Pittsburgh, 1912.
b. Analysis made during 1911 by the Bureau of Standards, Pittsburgh.

Miscellaneous analyses of Limestone in the York Valley Limestone Belt.

	1 (a)	2 (b)	3 (c)	4 (d)	5 (e)	6 (f)	7 (g)	8 (h)	9 (i)
$CaCO_3$,	91.58	91.40	43.728	49.92	98.35	94.12	91.48	78.57	80.96
$MgCO_3$,	4.11	7.29	6.45	42.98	0.16	1.85	0.90	1.09	9.62
Al_2O_3,	0.21	1.44	6.35	1.17	1.44	2.86	0.60	1.46	3.49
Fe_2O_3,									
S.,	0.113	0.003	1.48	0.22					
Insol.,	3.57	0.49	41.71	4.40	0.56	0.46	6.42	19.35	4.91
Undet.,						1.21	0.60		
Total,	99.583	100.623	99.718	98.69	100.51	100.00	100.00	100.47	98.98

	10 (j)	11 (k)
CaO,	36.816	38.500
MgO,	5.019	0.814
FeO,	2.443	2.228
MnO,	0.321	tr.
P_2O_5,	0.132	0.050
SO_3,	tr.	tr.
FeS_2,	0.065	0.041
CO_2,	35.550	31.632
H_2O,	0.350	1.055
$CaCO_3$,	-------	-------
$MgCO_3$,	-------	-------
Al_2O_3,	1.138	1.930
Fe_2O_3,	0.896	5.524
Insol.,	16.650	18.210
Total,	99.380	100.584

a, b, c, d. Compiled from Amer. Phil. Soc. Proc., Vol. 23, 1886, p. 406.
a. White limestone 100 yds., E. of Beeler's Cross Roads. 2 mi. N. W. of York.
b. Detwiler's quarry N. W. of Wrightsville.
c. Detwiler's quarry S. of Wrightsville.
d. West branch of Creitz Creek, near Wrightsville.
e, f, g, h, i. Compiled from Pa. Exp. Sta. Records. F. Menges, analyst.
j, k. Compiled from 2nd Geol. Surv., Pa. Rep. C., P. Frazer, Jr., 1876, p. 57, and Rep. MM., A. S. McCreath, 1876-8, pp.308-9. Both from Sprenkle's shaft, ½ mile W. of Menges' Mill Sta., P. R. R., "York, Hanover and Frederick Division."

Analysis of Lime From the Emigsville Quarry Co.

(Compiled from the 18th Ann. Rep. of the U. S. Geol. Surv., Part 5), Cont'd., 1896-7, p. 1066.

CaO,	90.68
MgO,	1.90
FeO, Fe_2O_3, Al_2O_3,	0.14
SiO_2,	0.53
H_2O, Undet.,	6.75
Total,	100.00

The following analyses (Ref. 21) shows some comparisons between various high calcium and magnesium limes:

(A). High Calcium Limes.

No.	SiO_2.	Al_2O_3 & Fe_2O_3.	CaO.	MgO.	CO_2H_2O, Etc.	Total.
1,	0.81	0.75	98.30	n.d.	n.d.	99.86
2,	0.36	0.15	98.13	0.42	0.80	99.86
3,	tr.	tr.	98.47	1.12	0.45	100.04
4,	0.12	0.12	99.29	0.46	n.d.	99.97
5,	0.20	tr.	98.84	0.12	1.02	100.00
6,	0.14	tr.	99.23	0.60	n.d.	99.97
7,	0.27	0.19	98.14	1.40	n.d.	100.00
8,	0.18	0.26	98.44	0.98	0.32	100.18
9,	0.30	0.42	98.24	0.56	0.54	100.06
10,	0.78	0.52	98.40	0.10	n.d.	99.80

Analysts quoted.

1.—Star Lime Co., Montgomery Co., Ky. R. Peter, analyst. Rep. A. Ky. Geol. Surv., p. 171.
2.—J. Follet & Sons, Renfrew, Mass. 20th Ann. Rep. U. S. Geol. Surv., Part 6, p. 410.
3.—J. P. Rich, Swanton, Vt. 20th Ann. Rep. U. S. Geol. Surv., Part 6, p. 455.
4.—Ibid. Loc. Cit.
5.—Ibid. Loc. Cit.
6.—W. B. Fonda, St. Albans, Vt., F. C. Robinson, analyst, loc. cit., p. 456.
7.—Follet Bros., N. Pownal, Vt. R. Schuppaus, analyst, loc. cit., p. 455.
8.—Ditto Lime Co., Marlowe, W. Va. J. A. Ditto, analyst, loc. cit., p. 459.
9.—J. B. Speed and Co., Milltown, Ind. Burk and Arnold, analysts. 28th Ann. Rep. Ind. Geol., p. 244.
10.—Horseshoe Lime and Cement Co., Bedford, Ind. Chauvenet Bros., analysts, loc. cit.), p. 256.

Magnesian Limes.

No.	SiO_2.	Al_2O_3 & Fe_2O_3.	CaO.	MgO.	CO_2H_2O, Etc.	Total.
1,	0.42a	----------	56.57	42.56	0.10	99.65
2,	0.80a	----------	58.00	38.45	2.80	100.05
3,	1.61	0.17	57.44	40.36	0.41	99.99
4,	0.46	1.10	55.49	42.31	0.64	100.00
5,	0.35	0.49	59.20	38.38	1.80	100.22

a. Inculdes Al_2O_3 and Fe_2O_3.

Analysts quoted.

1.—Canaan Lime Co., Canaan, Conn. J. S. Adam, analyst. 20th Ann. Rep. U. S. Geol. Surv., Part 6, p. 370.
2.—Marblehead Lime Co., Sandusky, Ohio. J. W. Skinner, analyst. Private communication to E. C. Eckel, U. S. Geol. Surv., Washington, D. C.
3.—L. McCallum and Co., Tiffin, Ohio. O. Wulte, analyst, loc. cit. (1), p. 433.
4.—Sheboygan Lime Works, Sheboygan, Mich. G. Bode, analyst, loc. cit., p. 464.
5.—Consolidated Lime Co., Huntingdon, Ind. T. W. Smith, analyst. 28th Ann. Rep. Ind., Dept. Geol., p. 289.

Results of Physical Tests.

In the testing (Ref. 25) of materials to be used for road building certain physical properties must be determined, the chief ones being: Hardness, toughness, cementing value and resistance to wear.

"By hardness is meant the resistance of a rock to the grinding action of an abrasive, like sand."

"By toughness is meant the resistance a rock offers to fracture, under impact; such, for instance, as the striking blow given by a shod horse."

"By cementing value is meant the binding power of the road material."

"Resistance to wear is a special property in a rock, and although it depends to a large extent upon both the hardness and toughness of the rock, it is not an absolute function of those qualities. (1).

1.—Compiled from the Division of Tests. Bureau of Public Roads. Dr. L. W. Page, Director. U. S. Dept. Agr., Form 28, 1-1-1911.

Quarry No. 1. B. Frank Beard, Wrightsville.

"Sample No. 5779. February 1st, 1912.

Material:—Dolomitic marble.

Determinations.

Specific gravity,	2.80.
Weight per cubic foot,	175 pounds.
Water absorbed per cubic foot,	0.14 pounds.
Per cent. of wear,	2.6.
French coefficient of wear,	15.3.
Hardness,	17.1.
Toughness,	13.0.
Cementing value,	Good.

Remarks:—Rather hard rock with average toughness, high resistance to wear and good cementing value. Should give satisfactory results under medium traffic."

Quarry No. 3. Benjamin H. Stoner, Hellam .

"Sample No. 5782. February 1st, 1912.

Material:—Crystalline limestone.

Determinations.

Specific gravity,	2.57.
Weight per cubic foot,	172 pounds.
Water absorbed per cubic foot,	0.18 pounds.
Per cent. of wear,	3.1.
French coefficient of wear,	13.1.
Hardness,	16.7.
Toughness,	7.0.
Cementing value,	Good.

Remarks:—This rock shows average hardness and resistance to wear, low toughness and good cementing value. Should be used only under light traffic."

Quarry No. 5. John Schum and Geo. A. Ruhl, York.

"Sample No. 5780. February 1st, 1912.

Material:—Limestone.

Determinations.

Specific gravity,	2.70.
Weight per cubic foot,	168 pounds.
Water absorbed per cubic foot,	0.48 pounds.
Per cent. of wear,	4.3.
French coefficient of wear,	9.3.
Hardness,	14.3.
Toughness,	3.0.
Cementing value,	Good.

Remarks:—Average hardness and resistance to wear, low toughness and good cementing value. Should only be used on roads subjected to light traffic."

Quarry No. 6. Harry S. Ebert and A. M. Hake, York.

"Sample No. 5783. February 1st, 1912.

Material:—Crystalline limestone.

Determinations.

Specific gravity,	2.75.
Weight per cubic foot,	172 pounds.
Water absorbed per cubic foot,	0.19 pounds.
Per cent. of wear,	3.1.
French coefficient of wear,	12.9.
Hardness.	14.8.
Toughness,	9.0.
Cementing value,	Fair.

Remarks:—This material shows average hardness and resistance to wear, low toughness and cementing value. Should be used only for roads subjected to light traffic."

Quarry No. 9. Emigsville Quarry Co., Emigsville.

"Sample No. 5778. February 1st, 1912.

Material:—Dolomitic marble.

Determinations.

Specific gravity,	2.80.
Weight per cubic foot,	175 pounds.
Water absorbed per cubic foot,	0.15 pounds.
Per cent. of wear,	4.6.
French coefficient of wear,	8.6.
Hardness.	14.3.
Toughness,	7.0.
Cementing value,	Good.

Remarks:—This material shows average hardness and resistance to wear, low toughness and good cementing value. Should be satisfactory for use under light traffic."

Quarry No. 11. York Stone and Supply Co., York.

Material:—Dolomite marble.

Material:—Carbonaceous limestone.

Determinations.

Specific gravity,	2.70.
Weight per cubic foot,	168 pounds.
Water absorbed per cubic foot,	0.44 pounds.
Per cent. of wear,	4.8.
French coefficient of wear,	8.3.
Hardness.	14.8.
Toughness,	7.0.
Cementing value,	Good.

Remarks:—This sample shows average hardness and resistance to wear, low toughness and good cementing value. Should be used only under light traffic."

Quarry No. 13. L. D. and Wm. A. Cunningham, York.

"Sample No. 5781. February 1st, 1912.

Material:—Argilaceous limestone.

Determinations.

Specific gravity,	2.80.
Weight per cubic foot,	175 pounds.
Water absorbed per cubic foot,	0.29 pounds.
Per cent. of wear,	2.8.
French coefficient of wear,	14.2.
Hardness.	17.3.
Toughness,	28.0.
Cementing value,	Good.

Remarks:—This is a hard rock, with high resistance to wear and good cementing value. Best suited for medium traffic roads."

RESULTS OF PETROGRAPHIC EXAMINATIONS.

Specimen 1.

Limestone from the quarry of Benjamin H. Stoner, Hellam.

A very compact, fine-grained limestone, dark-blue in color; contains much pyrite in the form of flattened cubes and much graphite.

Under the microscope it is seen to be a homogeneous, coarsely grained, aggregate of calcite, with an abundance of graphitic carbon and a subordinate amount of pyrite.

Specimen 2.

Limestone from the quarry of the York Stone and Supply Co., York.

A very fine-grained, dark-blue limestone.

Under the microscope it is seen to be a homogeneous, finely-grained aggregate of calcite, without definite crystalline form. Pyrite is sparsely disseminated throughout the mass, as minute grains.

Specimen 3.

From the quarry of the York Stone and Supply Co., York.

A very fine-grained, compact, dark-blue limestone, similar to specimen 2, but with crystals of quartz and pyrite. Often contains other minerals, as fluorite, dolomite, etc.

Under the microscope, it is seen to be a homogeneous, granular aggregate of calcite, similar to specimen 1, the calcite grains showing no crystal boundaries. Pyrite and graphitic carbon are present in subordinate amounts.

Quartz is common, and from the numerous grains of calcite enclosed in a section of a quartz crystal, would seem to be of secondary nature, i. e., replacing the calcite of the limestone. A grain of calcite, forming part of the aggregate, may lie partly within the aggregate and partly within the quartz crystal.

RESULTS OF PETROGRAPHIC EXAMINATION OF THE IGNEOUS ROCKS.

Specimen 4—Stony Brook or Loganville Dike. 4½ miles E. of York.

Macroscopically, this rock is fine-grained and compact in texture.

Under the microscope it is seen to consist of plagioclase, of the variety labradorite, twinned and geniculated; diallage, altering to serpentine; grains of magnetite and a little ferric oxide (limonite)) as an alteration product of the magnetite.

The rock is a diabase, whose pyroxenic constituents is diallage, altering to serpentine.

Specimen 5—Yest York Dike (Northeastern Extremity). 3½ Miles N. W. of York.

Macroscopically, this rock is fine-grained and compact in texture, similar to specimen 4.

Under the microscope it is found to consist of twinned and geniculated labradorite, in part kaolinizing; twinned diallage, altering to serpentine; magnetite, with crystal outline, replacing the dillage and also in the form of grains.

This rock is a true diabase, whose pyroxenic constituent is altering to serpentine.

Specimen 6—West York Dike. 2½ Miles W. of York.

Macroscopically, this rock is coarse-grained and compact in texture.

Under the microscope it is found to consist of twinned and geniculated labradorite; twinned diallage, altering to serpentine; minute crystals and grains of apatite; grains of magnetite and pyrite; and one minute plate of biotite.

Conclusively, this rock is a coarse-grained diabase, whose pyroxenic consistuent, diallage, is altering to serpentine.

Analyses of Diabase or "Trap."

	1. Stony Brook dike (Ref. 6).	2. West York dike (Ref. 4).
SiO_2	46.78	52.58
P_2O_5,	n. d.	0.15
TiO_2,	0.99	0.32
Al_2O_3,	19.28	14.35
Fe_2O_3,	6.11	5.98
FeO,	4.16	5.45
MnO.	tr.	tr.
MgO,	7.38	7.99
CaO,	9.11	10.27
Li_2O,	tr.	tr.
Na_2O,	5.10	1.87
K_2O,	0.52	0.92
Cu.,	----------	tr.
S.,	tr.	0.08
Ign.,	----------	1.23
CoO.	tr.	----------
H_2O (110°C.),	0.05	----------
H_2O (ab. 110° C.),	0.06	----------
Total,	99.54	101.09

Miscellaneous Petrographic Tests. Stony Brook or Loganville Dike. (Ref. 6).

"Labradorite; much diallage (pyroxene); common hornblende; some secondary hornblende, intergrown with microlitic felspar (plagioclase) and magnetite. Granular base. Conclusively, the dike is one of diabase. Has been much changed with the formation of much orthorhomibic pyroxene."

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APPENDIX E

THE GEOLOGICAL ORIGIN OF THE FRESHWATER FAUNA OF PENNSYLVANIA

By Dr. A. E. Ortmann.

INTRODUCTORY NOTE.

By R. R. Hice.

One of the most interesting subjects connected with the study of glacial geology is that of the determination of the lines of preglacial drainage. Western Pennsylvania has been the field for study of a large number of the Tertiary drainage lines and the features found in the State are prominent factors in the determination of the preglacial drainage systems of the entire eastern portion of the United States.

One of the earliest papers treating of the drainage features of Western Pennsylvania is that of Dr. Alfred T. King, on the "Ancient Alluvium of the Ohio and Tributaries," published in the proceedings of the Philadelphia Academy of Science, Vol. VII, 1856, in which he discusses the Alluvial deposits found on the rock benches above the level of the present rivers, which benches we now know are remnants of the beds of the old streams which drained Western Pennsylvania northward into the Erigan River and thence into the Atlantic Ocean.

The work of Carll, during the years of field work of the Second Geological Survey, in the upper oil fields of Pennsylvania, gave us a large contribution to our knowledge of the valleys of the preglacial streams which drained the upper Allegheny region northward into the present Erie basin. The information obtained from the vast number of well records he secured determined the present fall of the old river valleys is to the north, and no question has been raised since that time regarding the direction of their flow. In the

Appendix to Q4, published in 1881, is the paper by Dr. J. W. Spencer, on the discovery of the preglacial outlet of Lake Erie into the basin of Lake Ontario, through a channel west of the present Niagara River.

In report III, Prof. Carll says: "I strongly suspect that Big Beaver River is a glacial enlargement formed in the same manner as that found in the summit basins and, that anterior to the ice age, the Shenango and other head water streams, including the Connoquenessing, delivered northwardly through the Mahoning and Grand Rivers into Lake Erie basin." This was a suggestion of Prof. Carll without a full examination of the region. In 1890 Dr. P. Max Foshay (American Journal of Science, Vol. XL, p. 397) elaborated on this suggestion, showing an apparent northward slope of the buried floor of the present Ohio, Beaver and Mahoning Rivers from Pittsburgh to Edenburg, correlating the buried channels of the Ohio, Beaver and Mahoning Rivers with the buried channels determined by the work of Carll in the upper Allegheny region.

The earlier papers were largely based on the supposition of the unity of the glacial period, and the narrow buried channels known to extend below present river level were ascribed to a time preceding the ice invasion. With the closer study of the glacial period in this region, it was found it should be divided into at least two stages, the first corresponding to one of the earlier stages of the Mississippi Valley, Kansan or Pre-Kansan in age, and a later invasion corresponding to the Wisconsin stage of glaciation. Whether there were minor advances of the ice between there two invasions of northwestern Pennsylvania is not yet fully determined, but the interval between these two invasions was one of active stream erosion, and to it we now ascribe the excavation of the present system of buried channels.

This is not the time or place to discuss the literature of this problem as found in the many scattered papers and reports of Ashburner, Carll, Chamberlin, Chance, Claypole, Fairchild, Foshay, Gilbert, Hice, Jillson, Lesley, Leverett, Lewis, Spencer, Stevenson, Taylor, Upham, White, Wright and others, which bear directly upon the river history of Western Pennsylvania. The work of the several investigators has resulted in a mass of valuable information, and while the conclusions reached have not always been harmonious, there has been a "coming together" of the several theories and there is now a pretty general agreement as to the main facts.

We have in Western Pennsylvania the record of three distinct river systems, all occupying the same lines of drainage, but at different levels. Preceding the earliest ice invasion a complete system of drainage had been long established in Western Pennsylvania.

This bore no resemblance to the present system. In the north Allegheny region the streams were small, and flowed northward into the basin now occupied by Lake Erie, but then drained to the northeast by a great stream, which Dr. Spencer has designated the "Erigan River." The middle portion of the present Allegheny basin was

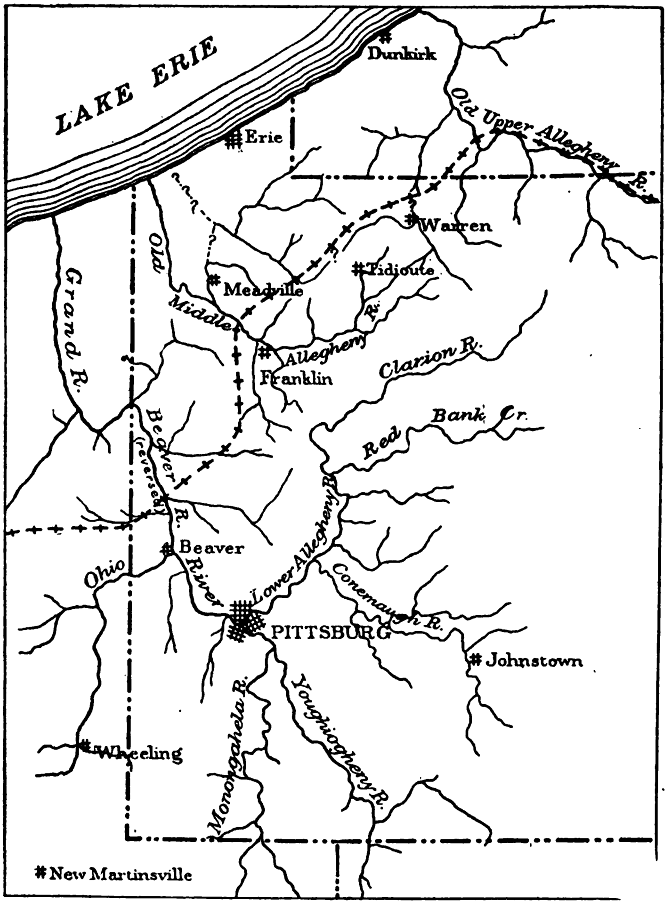

Fig. 1. Sketch map showing the probable pre-Glacial drainage of western Pennsylvania. The terminal moraine is shown by a broken crossed line. (Frank Leverett; with addition of terminal moraine.)

also drained to the northward by way of the present French Creek Valley, while the southern portion of the Allegheny basin drained southward, by the line of the present stream, to the site of Pittsburgh. At Pittsburgh this old preglacial stream was joined by the preglacial Monongahela, and the united streams flowed northward, by way of the present Ohio Valley, some 25 miles to the present site of Beaver. Here the stream was joined by one rising southward from Wheeling, in the highlands of West Virginia and southeast Ohio, and flowing

by the line of the present upper Ohio (reversed) to Beaver. From the present site of Beaver these streams, now a great river, flowed northward by way of the present Beaver (reversed) across the present preglacial covered divide into the Erigan River. The level of this old stream in the neighborhood of Pittsburgh was higher than the present Ohio, and its bed is marked by benches which are remnants of the rock bed of the old northward flowing stream. This old drainage system was one of great age and it had approached, if indeed it had not reached, the condition of a base level river. The evidences of the direction of the flow of this old stream are clear and distinct. First, there is the evidence of the present levels of the fragments of the old river bed. The slope of the fragments being in the direction of the flow above mentioned. Again, there is the evidence of the direction of entrance of the various tributary streams and the character of the bounding hills throughout the extent of the old river. In addition to other lines of evidence we have that of stream erosion as preserved to us in the rock bed of the stream at various points, which distinctly shows the direction of flow as that given above.

With the coming of the ice a new set of conditions arose. As the ice pushed southward across the present basin of Lake Erie, it slowly pushed its way up the slope of the southside of the basin, blocking in its progress the valleys of the streams which flowed northward, causing their waters to form into long finger-like lakes in the deeper portion of the valleys, and extending along the face of the ice to an extent determined by the topographic features. We know that this first advance of ice reached within a few miles of the present Ohio River at Beaver, crossing the present Beaver Valley near the mouth of the Connoquessing. The result of this was a damming back of the waters of this old north flowing stream at this point to form a large irregular shaped lake in the present valleys of the Beaver, Ohio, Allegheny and Monongahela rivers, the waters rising until they overflowed to the southwest at the lowest divide between the old stream and that draining westward from a point beyond Wheeling. This lake has been designated by Dr. I. C. White "Lake Monongahela," and it is one of the best defined and one of the earlier, if not the earliest, glacial lakes in the eastern portion of the United States. At the same time the northward discharge of the old drainage lines of the upper and middle Allegheny River were blocked and similar but much small lakes were formed, which overflowed southward over the lowest divide into Lake Monongahela. Along with the ice came vast accumulations of morainic materials, the products of centuries of decay, caught up and carried along by the advancing ice. It is evident that the ice and the morainic materials blocked the northern discharge until the southwesterly

flowing waters had cut deep into the divide and had established the line of drainage of the present Ohio River. It is possible the determination of this line of drainage was aided by an elevation of the eastern portion of the United States which has since largely disappeared.

Following the withdrawal of the ice it is probable this portion of the country maintained a higher elevation than at present. A time of quick run-off and rapid erosion followed, and a system of river channels was cut in the direction of the present flow to a depth below present water level. The conditions causing this deep cutting were not maintained for a great length of time, as is shown by the narrowness of the inner gorges and the fact that only the larger tributaries succeeded in eroding their beds to a depth corresponding to that of the major streams.

Following this period of deep trenching come the last invasion of the ice, accompanied, as it was, by enormous quantities of morainic material, pushed along and carried by the ice, and washed by the waters of the melting glacier down the present lines of drainage, silting these up to a height reaching about 125 feet above present stream level. The duration of this ice invasion was relatively short, and it has been but a brief time, geologically speaking, since the withdrawal of the Wisconsin ice from this region. Since the time of the withdrawal of this ice the present streams have been engaged in cutting their channels through the alluvial materials deposited by the waters of the melting ice. For long stretches the streams have been cutting away these gravels, but here and there they have been deflected across rock benches which were left in the cutting down of the inner gorge, and being thus retarded at places, there has resulted a series of rapids over the rock ledges which have retarded the down cutting of the streams, and helped to maintain their present level.

It is, of course, evident that this breaking up of the river history would mean great changes in the life of the waters and the accompanying contribution of Dr. Ortmann is most timely. The results of his pains-taking work bring out very strongly a fresh line of evidence regarding the preglacial direction of the flow of our streams, the changes which have occurred, and the fact that these changes were brought about by the glacial period, and it is a valuable addition to all that has been written. The complete verification it gives us of the direction of flow of these old streams, cannot but be pleasing to all students of glacial geology. Particular attention, perhaps, should be called to the evidences showing that the preglacial drainage from the Erie basin was to the northeast, where other lines of evidence of preglacial flow have largely been obliterated.

THE GEOLOGICAL ORIGIN OF THE FRESHWATER FAUNA OF PENNSYLVANIA.

By Dr. A. E. Ortmann.

At the present time, Pennsylvania belongs to three different drainage systems: the *Western* part drains into the Ohio and the Mississippi, and to the Mexican Gulf; the *Eastern* part sheds its waters to the Atlantic Ocean; and some sections of the *North* and *Northwest* drain into the St. Lawrence system. The latter, although also belonging to the Atlantic Ocean, should be distinguished from the rest of the Atlantic drainage (Potomac, Susquehanna and Delaware Rivers) for reasons which will become evident in the present paper.

This division of the drainage, in its present form, is of rather recent origin. Although there was, from the beginning, a drainage generally directed toward the East, and other toward the West, the special features have undergone much change during the gelogical past, and the present divides are not what they were formerly. Generally speaking, we may say, that the Atlantic system has largely encroached upon the Western, and that the Northern or St. Lawrence basin, in its present development is quite recent.

This contrast of the drainages and their geological changes should find an expression in the animal life inhabiting our rivers and creeks, and it is indeed a well known fact that, for instance, the Atlantic and the Western streams posses faunas which are rather sharply distinguished. Although this fact may not be very marked in certain groups of animals, there are others in which it is very evident. The fauna of the St. Lawrence and its tributaries is quite peculiar, showing affinities partly toward the East, partly toward the West.

In order to understand the origin and the development of our freshwater fauna, it is necessary to be acquainted with the *history of our drainage systems,* and a short sketch of the latter should be given first.

When the first land was elevated above the sea, freshwater streams began to flow. Geology teaches us that the whole of Pennsylvania is rather old land, although not all parts rose out of the sea simultaneously. The oldest parts are what is known as the *Piedmont plateu,* in the East: chiefly archaic and old paleazoic rocks, which became dry land in the beginning of the paleozoic era. This land formed a continuation, probably a peninsula, stretching out from a more extensive land mass in the North (the "Canadian shield"), south-

ward to a considerable distance South of Pennsylvania. This land, according to its greatly disturbed stratigraphy, probably formed originally a chain of lofty mountains, but it was worn down during the geological ages by running water, and transformed into a peneplain, which stood at times at base level, and was re-elevated at others. At one time (Trias-Jura) it was so much depressed that it was again partly covered by the sea.

To the West of this mass of old rocks of the Piedmont plateau there was, during the greatest part of the Paleozoic era, a sea, or rather a large bay extending from the ocean to the Southwest in a northeasterly direction. The western shore of this bay was in the present state of Ohio, being formed by the "Cincinnati uplift," its northern shore was the Canadian mass; and its eastern shore the Piedmont mountains. In this sea paleozoic strata were deposited, the most important of which are the famous coal beds of western and Central Pennsylvania. This bay was subject to a series of oscillations, its bottom being repeatedly elevated, and subsiding again, so that at times it became to a greater or lesser extent land, while it was at other times more or less submerged. These oscillations culminated in a general upheaval, connected with a lateral compression directed generally from Northwest to Southeast, which had the effect, that the beds deposited in the bay were compressed and folded up. The old rocks of the Piedmont plateau acted as a firm block, against which this lateral pressure was directed, thus causing the formation of a series of folds, anticlines and synclines, running generally in a northeast-southwesterly direction. The highest of these folds was located toward the East, immediately adjoining the Piedmont pleateau, while in a westerly direction the folds are less elevated and become gradually indistinct. This mountain-creating process was finished toward the end of the paleozoic time (Permian), and resulted in a system of subparallel mountain chains, generally known as the *Alleghenies.*

After this time, no important changes due to folding or warping took place. The whole region, with the exception of the comparatively small Trias-Jura transgression in the East, was never again submerged below sea-level, and Pennsylvania remained continental through the rest of the earth's history. But this land was subject to other changes of a different nature; erosion and denudation took place, the rivers which naturally began to develop upon this land tending to level it down again. And besides, there were again periodical oscillations, times of subsidence alternating with times of elevation. The first class never was important, and never carried the continent below sea level; the elevations were of greater consequence; after having been reduced to base-level, the country was lifted up

again, so that a new cycle of denudation could set in, and change the surface of the land.

If we try to imagine what the chief features of this old land were, we are to consider first the fact that the highest part of it was distinctly toward the East, in the eastern (or southeastern part) part of the Allegheny system. Consequently, this must have been the backbone of the land, from which the waters ran off in two directions; toward the East (or Southeast) into the Atlantic Ocean, and toward the West (or Northwest) into the interior basin. The latter drainage, however, must have been a very complex one. The Allegheny Mountains, consisting of a series of chains running more or less parallel to the highest eastern elevation, the water courses must have conformed to the general strike (Northeast to Southwest) at least in the beginning, and only by cutting across the various chains was it possible to establish the general Western or Northwestern drainage. This resulted in a system of streams running in their headwaters within the mountains, parallel to the strike of the latter, and breaking through the latter at various points in a Northwesterly direction.

In the second place we are to consider, that, since the highest mountains were located in the East of the system, the way to the Atlantic Ocean was much shorter and direct to sea level than on the Western side. Thus the power of erosion of the Atlantic streams was much greater than that of the western. The consequence must have been, that erosion was going on much faster on the Atlantic side, and thus a number of streams gradually sawed through the highest chain, the original divide, and not only through this, but also through some of the parallel ridges lying to the West of it. This resulted in what is called *stream-piracy*, the Atlantic streams advancing their headwaters westward, and tapping, robbing or capturing the Western streams, thus deflecting the course of their waters eastwards, and turning it directly to the Atlantic. This stream-piracy, and the continuous tendency of the Atlantic rivers to encroach upon the Western waters is the most prominent and important feature of drainage changes in the Alleghenies of Pennsylvania, and all the large Atlantic rivers (Delaware, Susquehanna and Potomac) show ample evidence of it, their headwaters occupying most of the present Allegheny mountain system, originally belonging to the western watershed.

These conditions prevailed all through the geological history from the end of the Permian to the end of the Tertiary. With the beginning of the Glacial period, however, changes of another character were introduced. But we cannot discuss these before we have considered the Western drainage more closely.

As has been said, the Western (or Northwestern) slope of the Allegheny system gave the original general direction of the drainage.

This drainage was toward the so-called interior basin, which, as is generally accepted hitherto, in turn drained into the Gulf of Mexico (or a northern extension of it). This is the Mississippi River. This may have been the case at certain times. But if we turn our special attention to the later periods, chiefly to the Tertiary, this Southern outlet of the interior basin becomes somewhat doubtful. The present writer is aware of the fact, that generally the existence of a Tertiary Mississippi is not questioned, and that it is taken for granted that in Tertiary times the Western slopes of the Alleghenies sent their waters finally to the Gulf of Mexico. Yet in the course of his studies (and of those of others) facts have come to light, which conflict with this assumption. He has tried to collect the evidence furnished by the distribution of freshwater creatures, but the geological and physiographical line of evidence is most important, and here the features of the interior basin are rather poorly known, at any rate, too poorly to permit a final conclusion with reference to the Tertiary drainage of the interior basin. Nevertheless, facts are at hand which indicate *that the Tertiary outlet of the interior basin was not to the South, but in the opposite direction, to the North and Northeast.* This means to say, that in the Tertiary there was no lower Mississippi River, and that the present Mississippi itself, as well as its chief tributaries, the Ohio and Missouri, are comparatively recent drainage features, and are directly due to and produced by the Glacial period, the advance of an ice sheet from the North, which stopped the northward flow of the waters, and forced them to seek another outlet, which they found by what is now known as the lower Mississippi.

It is not the place here to give the evidence for this hypothesis, but the writer hopes to be able to do so elsewhere. It may also be said that the evidence is by no means complete or conclusive; on the contrary, it is rather fragmentary, but the attention of geologists, physiographers and biologists should be directed to this fascinating question, and it is introduced here merely as a working hypothesis, which is capable of explaining certain facts, and for which additional evidence may be discovered. Here, I only intend to give a very general sketch of what I think might have been the drainage conditions of the interior basin in *Preglacial* times.

West of the Allegheny mountains is the Allegheny plateau. In its southern parts, this plateau extends considerably westward, and is known as the Cumberland plateau. It is then interrupted by the present Mississippi valley, but on the other side of the latter we find the elevation of the old *Ozark mountains* (in Arkansas, Missouri, and extending farther North). The Ozarks, again, are connected westwards with the high western plains, lying in front of the Rocky mountains system.

Assuming that the present Mississippi valley separating the Cumberland plateau and the Ozarks is of modern origin, and that these two elevations originally were connected, we obtain thus an interior basin, which is well defined by a southern elevation, which is also well defined toward the East, by the Alleghenies, and to the West, by the western plains and Rocky mountains, but has no sharp demarkation toward the North, and it is believed that in this direction toward the North, was the natural and original outlet of this great basin. And probably there were two outlets; one toward the North and the Artic Ocean, the other toward the Northeast, by way of the present St. Lawrence basin. The writer believes that the present Tennessee and Cumberland Rivers are the headwaters of the master stream running North (Old Mississippi), while the headwaters of the other, northeasterly flowing river are to be sought in the streams flowing down the northwestern slope of the Alleghenies in West Virginia and Pennsylvania.

The latter river-system concerns us especially, and happily, we are rather well informed about it, for it has been frequently discussed in literature. The master stream which collected all the waters coming from western Pennsylvania is known by the name Erigan river. As is generally conceded, it ran about along the axis of the present Lakes Erie and Ontario, but the direction of the flow is under dispute; some assume that it was toward the Southwest, while according to others it was toward the Northeast.

The latter assumption would agree with our theory. That there was no Ohio river in Preglacial times is a well supported fact, and all the streams of this region coming down from the Alleghenies and now emptying into the Ohio, once continued their course across the present Ohio valley, in a northwesterly or northerly direction, till they finally collected in the Erigan river, which, under our assumption, finally carried its waters toward the St. Lawrence Gulf.

If this was the case, we see that also the western drainage of the Alleghenies in Pennsylvania was an Atlantic drainage, a fact, which we should keep in mind, for it is important for the explanation of the origin of our freshwater fauna.

The advance of the ice sheet from the North, in *Glacial time,* could have but one effect upon these hypothethical preglacial streams. The ice, advancing mostly up hill, from the mouth toward the sources of the streams, must have acted as a dam, preventing the northern discharge of the waters, and must have first formed lakes in the valleys. The asumption of this lake-stage is well supported in our region. The waters of these lakes rose until they finally found an outlet, and thus, for instances, the Ohio was formed. The direction of the new outlet was naturally determined by the edge of the ice, and the slope

of the country. Similar conditions, *mutatis mutandis,* are known to have prevailed in the present Upper Missouri region, and, if the general theory is correct, the same processes which took place in details, must have taken place with reference to the entire system; the waters of the whole interior basin finally were forced to overflow at a certain point of the old southern divide, and this point is situated where now is the southern outlet, in the present Mississippi valley. This outlet probably was forced early in the Glacial period.

The history of the postglacial drainage in Pennsylvania is well known. When the ice retreated, lakes formed in front of it, which, in the beginning, drained South and Southwest, into the Mississippi. But later a new drainage was established, or rather a part of the Tertiary drainage was re-established, although modified, and the most important feature is the present St. Lawrence drainage, which carries part of the waters of the interior basin again toward the St. Lawrence Gulf and the Atlantic. The larger part, however, of the interior basin continued to send its waters through the new channel of the lower Mississippi into the Gulf of Mexico.

We come now to the consideration of the *origin and the development of the freshwater fauna of Pennsylvania.* The various groups of freshwater animals are of different value for this study. Some of them posses a distribution which is entirely unfit to be studied with this question in view. These are chiefly those groups, which possess unusual means of dispersal, that is to say, which are easily carried across land from one river system to another (by various agencies.) Others are more restricted in their distribution, and evidently meet difficulties in passing from one river system into others, unless there is an actual water connection. But again, some of the latter are too poorly known, and their distribution in Pennsylvania has not been studied sufficiently, to make an attempt at generalisation a safe task. In fact, there are only two groups for which satisfactory data are at hand; The crawfishes of the genus *Cambarus,* and the freshwater mussels or clams, the *Najades.* There are, however, other groups (fishes and certain Gastropods or freshwater snails), which very likely will prove to be important, but are not yet worked up.

As we have seen, the oldest differentiation of the drainages of Pennsylvania is that between the *eastern* and *western* slope of the Alleghenies. This is well expressed in the fauna. Of course, we cannot expect that paleozoic (Permian) conditions are recognizable, since it is hard to demonstrate that any forms of our freshwater life go back to these times *a.* The most important changes of our drainage system took place later, in the Tertiary and Glacial periods, and thus we should look for indications of these conditions in our present fauna.

a. Cryptobranchus and Necturus, our great salamanders surely are very old, but it can hardly be said that they express paleozoic conditions.

The difference of the Atlantic fauna from the western is rather striking in the two groups named above. Nevertheless it is evident that the Atlantic fauna is not fundamentally different from the other, but shows certain relations to it, which we should be able to connect with the past history of the drainage systems. In the groups studied by myself, crawfishes and mussels, this relation is clearly expressed by the fact that practically all Atlantic forms show affinities to forms existing somewhere in the central basin. On the other hand, there are many forms in the interior basin-fauna, which are entirely absent in the Atlantic fauna. This leads to an important conclusion: *the interior fauna is the older one, and the interior basin was the center of origin of all these forms, and the Atlantic side received its forms secondarily by migration from the interior basin.* This brings up the fundamental question; which was the route of migration, by which the Atlantic slope was populated, and we are to discuss several possibilities in this report.

1. *The crossing of the divide.* This may have taken place at any time during the history of our continent, and may have been possible in different ways.

a. The most simple way is by *migration or tranport over land,* but this involves that the forms concerned must be able to go out of the water, and to walk over land, or that they are able to stand transport over land or through the air (by birds, for instance). In certain groups of freshwater animals, chiefly the smaller forms, this seems to be a regular way of dispersal, and we know indeed a great number of creatures which apparently have formed their distribution under the influence of this factor. Naturally the present distribution cannot indicate much of the original conditions any more, and these are just the cases of which I have said above that they do not furnish much enlightment as to the study of the origin of the distribution of the freshwater fauna. One case of a crayfish should be mentioned especially: *Cambarus bartoni,* which lives in small streams on either side of the divide, and undoubtedly is able to cross over from one system into another. From its distribution alone, we would be unable to tell, whether it belongs originally to the eastern or western side.

b. Another way of crossing the main divide of the Allegheny mountains is offered by *stream piracy.* We have seen that the Atlantic drainage has largely encroached upon the interior drainage, and by taking away and deflecting the waters of a western stream, it is only natural that also the fauna contained in it should be taken over toward the Atlantic side.

This is apparently the case in a number of instances. When the freshwater forms originally lived in the headwaters of the interior drainage this must have happened rather regularly, and it should be

a general phenomenon. But the fauna of the headwaters is not very rich in forms of those groups which have been more closely investigated. In the case of the crawfish *Cambraus bartoni,* mentioned above, the dispersal by this way probably has taken place as well as by migration over the divide. Among the mussels, we have a few cases, in which this dispersal is suggested: *Strophitus edentulus* and *Alasmidonta marginata.* In the first, the Atlantic form is absolutely undistinguishable from the western, in the second, the Atlantic form represents a geographical race of the western, with which it intergrades, however. Both are eminently characteristic for small streams, and go up very far in the headwaters, while they are scarce or missing in the large rivers. The possibility of the crossing of the divide in consequence of stream-piracy thus becomes very likely, and I do not hesitate to regard these cases as due to this factor. The time of this crossing cannot be ascertained, for it might have been at any time, but the probabilities are for this having happened in the Tertiary. It may happen again at any time.

I have not been able to obtain any evidence as to the special region in which the crossing was effected in the case of *Strophitus edentulus.* As to *Alasmidonta marginata* and its eastern variety *varicosa,* there is very positive evidence that it was in the headwaters of the *West Branch of the Susquehanna,* for in this region a shell is found, which is more nearly like the western shell, in fact is a perfect intergrade.

In addition, recent studies have brought to light a third case, *Symphynota viridis.* This shell was known hitherto to exist only on the Atlantic slope. But it is also in the headwaters of the Kanawha river in West Virginia, and from here (New river) it apparently crossed over by stream piracy into Virginia, and spread out into other Atlantic rivers.

Also another case of a crawfish should be mentioned in this connection, that of *Cambarus diogenes.* Practically identical forms of it are found East and West of the mountains, but not in the mountains. This case, however, is yet obscure, and requires further investigation (see below).

2. The fact that the representative forms on either side of the mountains are identical or at least conspecific, is important. *In all other cases, to be discussed presently, specific distinctness of the Atlantic and the western form representing it is positively assured.*

Looking over these cases, we may distinguish, in the Atlantic fauna, *two elements:* the one possesses distinctly relations in the fauna of the interior basin, if not in western Pennsylvania, somewhere in other parts of the Ohio-drainage. It is not always a group of two species, which is thus related, but sometimes on the one or the other side several species may be concerned; and further, it is almost a general

rule that these species do not go into the mountains, or at least remain away from the small mountain-streams.

The following instances are at hand:

Cambarus indianensis and *sloanei* of the Ohio drainage in Indiana and Kentucky are represented on the Atlantic side by *C. limosus.* The latter goes from southern New York to Virginia, but farther South no trace of a representative form is found.

Alasmidonta calceolus, distributed westward from eastern Ohio, is represented on the Atlantic drainage by *Alasmidonta heterodon,* which goes from New England to Virginia, but not further South.

Anodonta grandis, of wide distribution westward from western Pennsylvania has a representative in eastern Pennsylvania in *Anodonta cataracta.* The latter is found from Maine and Canada to North Carolina. Allied forms are found southward to *Georgia,* but hardly westward on the coastal plain of the Gulf.

Lampsilis luteola, a common form of the Ohio drainage, is represented East of the mountains by *Lampsilis radiata,* which spreads from Canada and New York probably to Georgia, but disappears farther South and West.

Lampsilis ventricosa (and some closely allied forms), common in the Ohio drainage, have in *Lampsilis cariosa* and *ochracea* their representatives on the Atlantic side; both go from New England to Virginia, but hardly farther South.

In all these species we observe one striking fact on the Atlantic side; their distribution is rather restricted to the *northern sections* of the eastern slope of the Alleghenies, the adjacent Piedmont plateau and the Coastal plain. In general they go southwards to Virginia and the Carolinas, rarely a little farther South, but there is no expansion of these types westward over the coastal plain of the gulf. Thus their center of distribution and of development is distinctly in the Northern section of the Atlantic slope, and this suggests that they did not come from the South, or else traces of this migration should have been left there. On the other hand, we see that the western species most closely allied to these Atlantic forms are uniformly found in the present Ohio drainage, i. e., in the northeastern section of the interior basin, which, as we have seen above, was supposedly drained, in Preglacial times, by the Erigan river. If our conception of this drainage is correct, i~~s~~ was part of the Atlantic drainage, and thus it would not be astonishing that the eastern forms representing them belong to the northern part of the Atlantic slope; for the latter probably was much better developed in the North in the past. It is entirely possible, that the western species having reached the lower parts of old Erigan river (present lower St. Lawrence region), spread southward over the coastal plain, because

it is well known, that the chances of migrating from one river to another are much more favorable in the lowlands, than farther upstream.

We thus come to the conclusion, that these forms, the crawfishes and shells named above, reached the Atlantic slope *by going around the Allegheny system in the North*; by a northern route of migration, which followed down Tertiary Erigan river to the northern parts of the Atlantic coastal plain, and then along this plain to various distances to the South. But this migration did not reach the Gulf plain; generally, it stopped in Virginia or the Carolinas.

With the advent of the Glacial period important changes took place with regard to this Erigan-Atlantic fauna. The ice covered all of the lower system of the Erigan river, killing its fauna, and restricting it to more southern parts, and there were only two chances for this fauna to survive; in the southern headwaters of the original Erigan system, west of the mountains, and in those parts of the Atlantic system, which were not covered by the ice (from New Jersey and eastern Pennsylvania southwards.) This produced an interruption of the originally continuous range, and these two glacial "refugia" of this fauna became separated from each other. This separation probably was the essential factor tending toward specific differentiation of the eastern and western forms. The present distribution of the Atlantic species into the glacial area of New York, New England, etc., of course, must be regarded as a postglacial expansion of the range.

3. We have another group of freshwater forms in the Atlantic drainage of Pennsylvania, which shows entirely different conditions with regard to systematic affinity and geographical distribution. The following cases illustrate this:

Cambarus blandingi is found on the coastal plain from New Jersey and southeastern Pennsylvania *b*, southwards over the whole Atlantic and Gulf plain, and goes up the Mississippi valley to the region of the Great Lakes. The western form is distinguished as a variety. The centre of the group, to which this species belongs lies unmistakably on and at the foot of the southern extremity of the Appalachian system.

Unio productus (and a few closely allied forms) goes northward to the Potomac drainage in southeastern Pennsylvania. It is a southern type of shell, going to Georgia, and to the Gulf plain. No closely related forms are found in the interior basin.

Unio complanatus, goes from New England to the Gulf plain, and has no allied forms in the interior basin.

Alasmidonta undulata, is distributed from New England to North

b. This species is not mentioned as found in Pennsylvania in my memoir on the crawfishes of this State. It exists, however, as I discovered subsequently, in great numbers in the ditches of the Delaware meadows at League Island, Philadelphia.

Carolina, and has some closely allied forms in South Carolina and Georgia. This type of shell is entirely missing in the interior basin.

The difference in the distribution of these species (from those discussed under 2) is quite evident. The center of the distribution of them is located emphatically *in the southern section* of the Atlantic slope, or even upon the Gulf plain, and closely allied forms are not found in the interior basin, or (in *Cambarus blandingi)* do not belong to the northeastern section of it. This teaches us, that we have to assume, for these four forms, a southern centre of dispersal, and that their presence in Pennsylvania must be explained by a northward migration along the Atlantic coastal plain. The time of this migration is hard to define, for they may have come at any time. Of course, the expansion of these species into the glaciated area (North of New Jersey) must have been postglacial.

The above discussion leads up to the assumption of a *fourfold origin of the freshwater fauna of the Atlantic drainage of Pennsylvania:*

1. Species which are liable to be regularly dispersed by passive transport or active migration over the divide formed by the Allegheny mountains.

2. Species which have been transferred from the western to the eastern drainage by stream piracy.

3. Species which reached the Atlantic side by a round about way, coming from the western side, but going around the mountains in the North.

4. Species coming from the South, from a centre of radiation situated in the southern Atlantic or Gulf coastal plain.

We have yet to discuss the origin of our *western* and *northern* fauna. As has been said, the *western* fauna probably belonged originally to the old Erigan river, and in Preglacial times there was no northern fauna differentiated. The Erigan fauna undoubtedly belongs to the fauna of the interior basin, at least it must have been derived from an old, Preteriary, general fauna of the interior basin, There are no data at hand, at the present time, which enable us to distinguish the two old faunas of the Erigan river and the old Mississippi flowing to the North. *c.* This task is difficult, for the system of these two old rivers probably frequently intercommunicated from the Cretaceous to the Glacial periods. We have reason to assume that the fauna of the interior basin, in a large part, originated in the West and Southwest of our continent; but during part of the Cretaceous, and in the Tertiary it formed an independent centre of differentiation and radiation, from which waves of migration spread in all directions *d.*

c. I have succeeded, however, in one case, to correlate the distribution of certain western cawfishes of the Cambarus prolinquus group with the preglacial courses of the tributaries of the Erigan river. I cannot introduce this evidence here, since the region concerned lies largely outside of our State.

d. One important and comparatively ancient wave went over the southern divide from Tennessee into the Alabama system, developing there into an additional, secondary centre.

The development of the *northern* (St. Lawrence) fauna is quite clear. As we have seen, the northern parts of the Erigan drainage were covered by the ice. At the beginning of the retreat of the ice, it was transformed into a part of the Mississippi basin, and the waters which collected at the southern edge of the ice-sheet discharged into this common outlet, and thus it is to be expected, that the fauna of the Great Lakes and the present St. Lawrence, which originally were parts of this drainage system, should show distinct affinities to that of the Ohio-Mississippi.

This is indeed the case. We have in Pennsylvania, in Lake Erie and its drainage, a distinctly *western* fauna of crawfishes and shells. The only lake-species of crawfishes, *Cambarus propinquus,* is western in its distribution, and among the mussels we have the same conditions, at least in the majority of the cases. Of about 22 species of Najades known to me from the lake-drainage in Pennsylvania, 21 distinctly point to an immigration from the West, probably in most instances through the old Maumee River, which once flowed toward and in the direction of the Wabash. This immigration, of course, falls in the Glacial time. At the end of the Glacial time this western discharge was reversed, and the waters began to flow again in a northeasterly direction. With this the present St. Lawrence system was inaugurated, and its fauna became separated from that of the Ohio-Mississippi. This afforded a chance to the St. Lawrence species to start upon different lines of evolution, and we may observe, indeed, and chiefly so under the peculiar environment furnished by Lake Erie, that most of these types of the interior basin show a distinct tendency to become different in the lake; they are mostly sharply marked local races, if not good species.

I have tried to give above a general sketch of the geological origin of our freshwater fauna, quoting particular instances, in which the origin is rather clear. We see that we have three chief groups among our freshwater animals: western, eastern and northern. The western element is the oldest, and forms part of an old fauna of the interior basin, which goes back at least to Pretertiary times. The eastern fauna generally immigrated into the section, where it is now found, along routes set forth in detail above. It can be traced back to the fauna of the interior basin, and consequently must be somewhat younger. The northern element in our fauna is the youngest, but also goes back to that of the interior basin.

For the present there is no indication that there ever was an independent centre of development and radiation of freshwater creatures on the eastern side of the Alleghenies. But instances of this kind may turn up.

In conclusion, I should add a few isolated cases, which do not fall

under the rules laid down above, and require special explanation. Some of these cases are yet rather obscure.

1. The burrowing crawfish, *Cambarus diogenes,* mentioned above, is found both in western Pennsylvania and in the most eastern parts (Delaware lowlands.) The difference of the two forms are very slight and hardly amount to much. The eastern and western ranges of this species seem to be entirely discontinuous, but the facts of the distribution, chiefly in the South, are incompletely known. For the present it is impossible to classify this case, and considering that this form with its peculiar habits (burrowing) must be subject to laws different from those governing the distribution of other freshwater creatures, we are to expect that the explanation also must here form a class of its own.

2. We have in Lake Erie and in the Delaware river drainage a species of shell, *Lampsilis nasuta,* in which individuals from the two sides are absolutly undistinguishable. In our Atlantic drainage, this species is restricted to the Delaware, and is not found in the Susquehanna and Potomac. Northward it is widely distributed over New York, and goes to New England. Westward it goes through the lake-region. In the Mississippi drainage it is represented by an allied species. At the first glance, we might class this with the rest of the Lake Erie forms, and take it for modified form of the interior basin. But its occurence in the lower Delaware (abundant near Philadephia) is exceptional. It is possible, that here it is a very recent imigrant, coming from the St. Lawrence drainage through Erie canal (see below) but this explanation does not seem to be very satisfactory, because other forms, which have spread eastward through the canal do not have the same distribution.

3. A very singular case is seen in the distribution of the freshwater pearl-mussel, *Margaritana margaritifera*, which is found in Pennsylvania, exclusively in the headwaters of the Little Schuylkill river, in Schuylkill county. This is the most southern extension of its range in northeastern America, where it goes northward as far as New Foundland. It is the only species of North American Najades, which is found outside of our continent (northern Europe and Asia). This distribution is quite unique, and forms a case by itself, and it is clear that it cannot be connected with the general centre of our Najades in the central basin. The generally accepted opinion is, that in Preglacial times, *Margaritana* had a more or less circum-polar distribution and that it came to this country by way of Iceland and Greenland. Its range was largely destroyed in Glacial times, but at certain places it survived South of the edge of the ice. One of these glacial preserves (refugia) was in the mountains of eastern Pennsylvania, and this species is to be regarded as a *glacial relic* in Pennsylvania.

Its present range in northeastern America, of course, is due to postglacial migration.

4. Finally we are to consider the cases of recent changes of distribution. They have been brought about by human action chiefly by the building of canals, which connect different river systems, and thus give to the fauna an opportunity to spread. Such changes have been pointed out by the writer in certain species of crawfishes: *Cambarus limosus* of the large eastern rivers has migrated largely along the Pennsylvania canal; *C. obscurus* of western Pennsylvania has invaded the Erie drainage probably through the Erie-Beaver canal. In one case, the western *C. obscurus* has been found in Wills creek, in Bedford county, in a tributary of the Potomac. This we cannot explain except by artificial transplantation *e*.

Among the mussel-shells, we may have similar cases, at least in one region, namely in northwestern Pennsylvania, along the route of the old Beaver canal. Here we have a number of species, which are found exclusively in the headwaters (or the whole system) of Beaver-Shenango river, and the tributaries of the Upper Allegheny river, but nowhere else in Pennsylvania. These species are: *Quadrulla kirtlandiana, Symphynota compressa, Symphynota coumplanata, Anodonta imebillis, Anodontites ferussacianus, Lampsilis parva.* But since the original conditions in this region are unknown, we cannot decide, whether the Beaver canal was responsible for these conditions, or some older natural connections of these systems.

In New York State there is direct evidence that the Erie canal helped in the eastern extension of the range of certain western species.

It is to be hoped that further study of our freshwater fauna will advance our knowledge of it and most desirable would be the study of such groups, as are not mentioned in this paper.

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e. New light has been shed upon this case in recent times. I won't discuss it here, since the region concerned lies chiefly outside of our State.

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APPENDIX F

A PERIDOTITE DIKE IN FAYETTE AND GREENE COUNTIES.

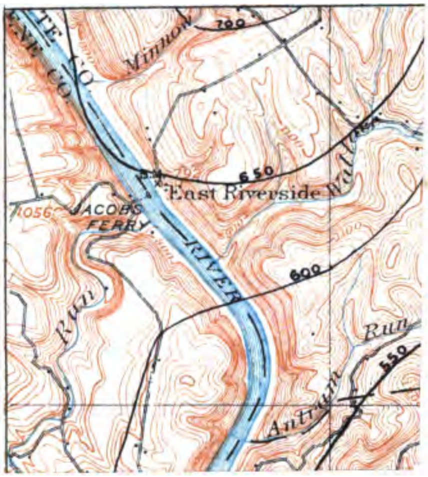
BY LLOYD B. SMITH.

INTRODUCTORY NOTE.

This occurance of peridotite is believed to be the second of the kind in the Appalachian coal field, the other being in Elliott county, Kentucky (See U. S. Geol. Sur. Bull. No. 38). In Livingston and Crittenden counties, Kentucky, a mica-peridotite is found, but it occurs in a fault (associated with vein matter, chiefly fluorspar), with a vertical throw of at least 800 feet (Diller, Am. Jour. Si., 3rd. Ser., Vol. XLIV, p. 286, 1892). The finding of the top of the dike in the Waynesburg sandstone, and the thrusting of a block of the same upwards is of interest, and it must be noted the amount of metamorphic action is less than would be expected.

There is but little evidence regarding the age of the dike. That the intrusion was not until after the deposition of the shales overlying the Waynesburg sandstone is evident. It seems equally clear it is preglacial in age, or at least older than the last ice invasion, for it was earlier than the abandonment of the benches which mark the horizon of the Monongahela waters preceding at least a portion of the ice invasion, else we should find surface flows from the fissure. It seems hardly possible the time of the intrusion can be fixed closely.

The location of the dike seems to have much in common with that in Elliott county, Kentucky. In describing the latter, Mr. Diller quotes Prof. Crandall as follows: "The dike is found near the junction of two lines of flexure; one parallel to the axis of uplift of the coal measures and the other a transverse or secondary undulation of considerable local prominence." (U. S. Geol. Sur. Bull. No. 38, p. 29). How far the slight "cross folding" present at Gates may have been effective in producing the rupture which allowed the molten mass to rise is of course mere conjecture. If sufficient to cause the rupture we should expect at least some vertical displacement, of which there



[1]Annals N. Y. Academy of Science, Vol. 17, part 2, Sept., 1907, pp. 509-518.

County. The most acessible exposure of the dike is on the North bank of Middle Run, about a half mile east of its junction with the Monogahela river, where is situated the coal mining town of Gates. The dike can be seen opposite the east end of a row of Company houses, a hondred and fifty feet west of the small church. Extending from this exposure in a line that does not vary more than a degree or two from 52 degrees west of north, it is exposed in at least seven other places, where it outcrops in the beds, or high up the sides, of the numerous ravines crossing its course.

The Edenborn and Gates mines of the H. C. Frick Coke Company, give an excellent opportunity to study the dike underground for a distance of about three miles.

The Pittsburg coal in the Gates mine is 240 feet below the river level, and the Waynesburg coal is 380 feet above the Pittsburg. The intervening strata are principally limestone and sandstone, with a few beds of shale and coal. The dike cuts the Waynesburg coal but cannot be found more than 35 feet above it in the Waynesburg sandstone.

The structure of the stratified rocks at this place is that of a broad trough, or syncline, running northeast and southwest, with the gentler slope to the northwest. The course of the dike is almost at right angles to the axis of this trough.[2]

The average thickness of the dike on the surface is about three feet. In nearly every exposure two or more narrow branches can be seen, from two inches to a foot in thickness, and running parallel and close to the main dike. On Middle Run two small branches occur 70 feet northeast of the main dike. They are five and three inches wide respectively, with 18 inches of shale between. Again in the run east of Adah it is double, the southwestern branch appearing as a horizontal sheet or sill, eight inches thick, under six inches of coal, and about 80 feet from the main dike.

Plate XXI A, shows its occurance in the bed of Middle Run, about 80 feet under the Waynesburg coal. Here it has followed a thin coal seam about four feet to the southwest, before rising again in a vertical direction. The thickest part is here three feet wide, but three branches and included shale make a dike zone six feet in width.

The dike spreads locally just above the Waynesburg coal on the north bank of Middle Run to 10 feet. The Plastic or molten condition of the rock at the time of flow, and the direction of its movement, are well shown here, for the dike spread out and enclosed a large block of coal with its overlying shale and lifted it above the

[2]The deepest portion of this trough will be found in the northeast corner of the area covered by Plate XIX, where the Pittsburgh coal reaches down to 450 feet above tide. The axis rises towards the southwest from this deeper portion, and at the Gates mine has risen to about 550 feet. It continues to rise to the southwest for about two miles, when it again pitches downward, reaching below 550 feet above tide and forming the Whiteley syncline. Gates, therefore, occupies a position where there may readily have been, and may still be, a very considerable strain on the rocks, at approximately right angles to the general direction of folding. (R. R. H.)

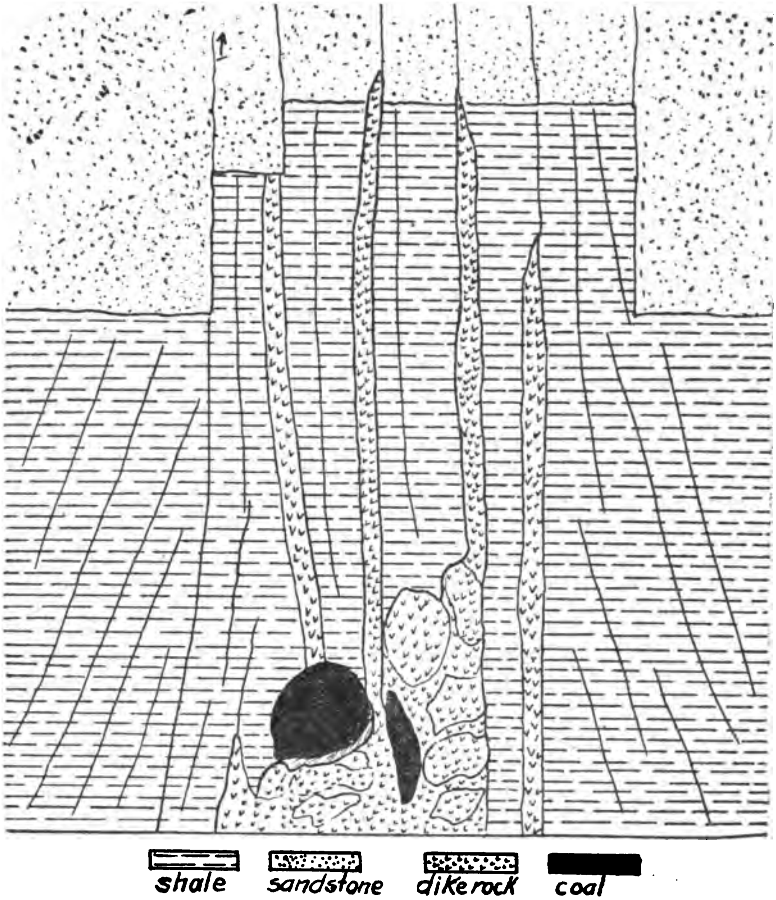
A.

Plate XXI. Views showing dike on Middle Run.

B.

View of dike above the Waynesburg Coal, Middle Run.

level of the coal seam. This condition is shown in Plate XXI B. Just above this the shale, which is here about 15 feet thick between the Waynesburg coal and the Waynesburg sandstone, has been lifted by the pressure of the molten mass, so that a zone 12 feet wide has been raised four feet (see Figure 2).



Outcrop on Middle Run over Waynesburg Coal.

Figure 2.

Underground a maximum thickness of 20 feet was observed in the Gates mine. It consists here of two branches, one that is 20 feet in width, and one 18 inches, with 80 feet of coal between. In another place in the same mine widths of three feet and six feet were observed, with 30 feet of coal between. The thick places are undoubtedly only local swellings, for the coal seems to have allowed the liquid magma to spread more readily than did the other rocks.

In the Edenborn mine on the southeast two branches are observed, twelve inches and four inches wide, with 12 inches of coal between. The dike pinches out in this mine, but the jointed condition of the rocks along the course of the dike can be traced in this mine 1,800 feet farther to the southeast.

The farthest that it can be traced to the northwest is at an opening in the Waynesburg coal near the head of a small ravine in Greene county, on the west bank of the Monongahela river, about three fourths of a mile north of Brown's Ferry. This ravine runs to the southeast and undoubtedly owes its course to the line of weakness caused by the jointing of the rocks parallel to the dike. The dike at the head of this ravine can be seen as a fissure in the coal, 27 inches wide, filled with decomposed clay-like material. This material is a rusty earth, in which can be found garnets, and nodules of magnetite and olivine.

Some of the coal close to the dike appears to have been coked, and fifteen feet away it appears like a semi-anthracite. The most noticeable effect upon the coal seems to have been in the developement of a laminated or platy structure in a zone extending fifty feet on each side of the dike. These sheets, or lamniae, are from one-half to two inches thick an dip away from the dike at a high angle. The ordinary jointing of the coal has been destroyed in the developement of this lamination.

The actual contact of the dike with the limestones can be seen in several places, but the limestone does not seem to have been noticeably affected by the dike material.

The shale within a few inches of the dike has been changed to a red color. This is probably due to the action of heat on the iron compounds, as is the case in the manufacture of brick. Within 50 feet of the dike the shale also shows many joints parallel to the dike or dipping away from it at a high angle.

The more rigid sandstone has been affected to a greater distance than the other rocks. Over a zone fully 200 feet wide very pronounced parallel joints are noticed. This jointing is so noticeable that it was used to advantage as an aid in tracing the dike. Fig. 3 shows the direction and distance apart of a few of these joints 120 feet northeast of the main dike on Middle Run. The jointing is parallel to the dike, and dips 80 to 85 degrees away from it. The jointing makes poor roof conditions in the mines along the line of the dike.

At the outcrop the rock is much weathered and of a brownish green color. It shows as spherodical masses which are tough and fracture with difficulty. The weathered surface has a characteristic appearance, due to protruding nodules of olivine. The final result of weathering is a yellowish brown earth, containing scales of bleached biotite. Where found in the mines the dike rock is of a darkker color and more

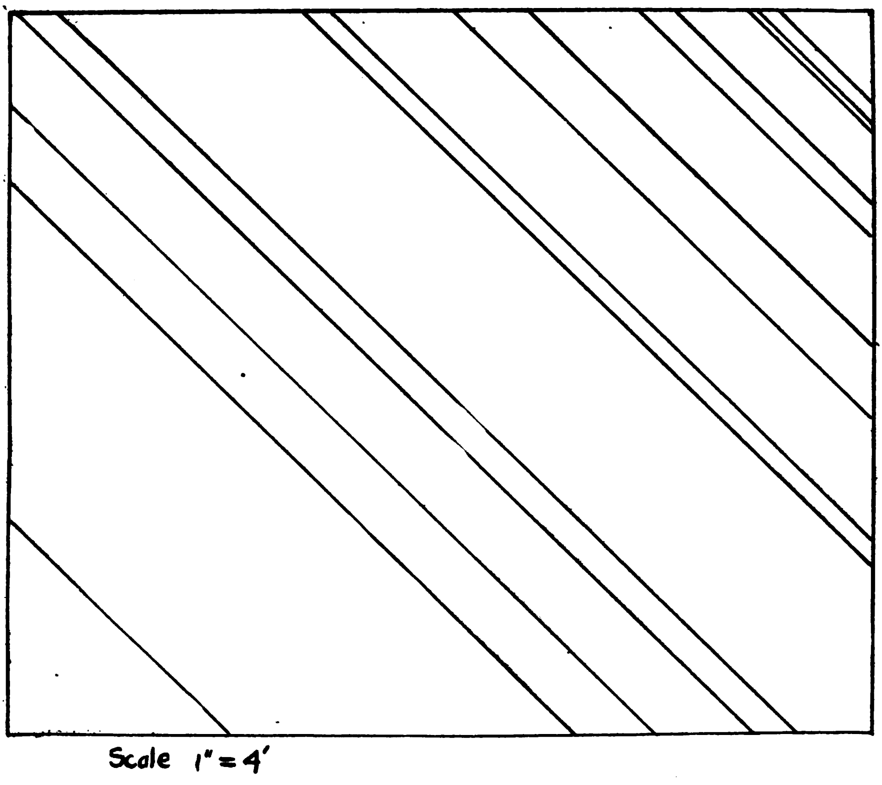


Figure 3.

crystalline in appearance than the surface exposures. Numerous small phenocrysts of biotite, a fraction of a millimeter in diameter, and occasionally one from one to two centimeters in diameter were noticed. There are nodules up to two centimeters in diameter of olivine partly altered to serpentine, nodules of magnetite up to one centimeter in diameter, and a few garnets are also visible to the unaided eye. The ground mass is dark colored and compact. Inclusions of coal, changed to coke, and of the other rocks through which the dike has cut are numerous.

Under the microscope biotite is much in evidence and is decidedly pleochroic. The biotite has no regular arrangement except around the nodules of olivine, where it is parallel to their periphry. Phenocrysts of serpentine showing the shape and cleavage of olivine crystals leave little doubt as to the original abundance of olivine. Magnetite is fairly abundant. The nodules before mentioned are primary, while the small grains in many cases are secondary. Ilmenite is also quite abundant. Making up the entire ground mass and extending into the cleavage cracks of the altered olivine phenocrysts is dolomite and calcite. This has resulted from weathering and makes the original condition of the ground mass difficult to determine.

In the paper by Ross and Kemp an analysis of this dike is given which is here reproduced. For comparison the analyses of the dike material from Elliott county, Kentucky, and of the mica peridotite dike from Crittenden county, Kentucky, are also included.

	Fayette County, Penna.	Elliott County, Kentucky.	Crittenden County, Kentucky.
SiO_2,	28.83	29.81	33.84
TiO_2,	5.67	2.20	3.78
Al_2O_3,	2.94	2.01	5.88
Cr_2O_3,	----------	.43	.18
Fe_2O_3,	3.60	5.16	7.04
FeO,	5.13	4.35	5.16
MnO,	----------	.23	.16
NiO,	----------	.05	.10
MgO,	24.31	32.41	22.96
CaO,	11.24	7.69	9.46
BaO,	----------	----------	.06
Na_2O,	.75	.11	.33
K_2O,	1.31	.20	2.04
H_2O,	3.96	8.92	7.50
H_2O-,	.83	----------	.68
CO_2,	11.64	6.66	.43
Cl,	----------	----------	.05
P_2O_5,	.77	.35	.89
SO_3.	----------	.28	----------
	100.98	100.86	100.54

From all the information at hand it is evident the dike is later than the Permian and is pre-glacial in age, but nothing more definite can be said regarding its age.

APPENDIX G

THE MINERAL PRODUCTION OF PENNSYLVANIA.

By Richard R. Hice.

General Statement.

The primary purpose of a Geological Survey is the encouragement of the mineral production of the State. That this may be accomplished it is not only desirable, but it is necessary, that the Geological Survey be in close touch with the various producers of minerals within the State, and also with the value of the output; and the greater detail of this information, the more valuable and accurate will be the knowledge and the greater the benefit derived from the organization.

In order to carry out as fully as possible the purposes of the Survey, it was arranged late in the fall of 1911 to co-opearte with the United State Geological Survey in the collection of the mineral statistics of the State. An arrangement was made which was most advantageous to the State Survey, by which much of the expense and labor of the work; the cost of printing the necessary blanks, the mailing of the same, and the franking of the replies from the many producers, are all borne by the United States Survey. The reports of production under this arrangement are sent directly to the office of the State Geologist, where the desired information is taken from the same, and they are then forwarded to the United States Survey at Washington. The State Survey aids in the collection of the reports of those who fail to make reply by mail. By this arrangement both surveys are represented and the producers are only required to make one report.

The experience of this, the first, year under this arrangement has been more than satisfactory and it is hoped and expected the arrangement will be continued. The State of Pennsylvania has over 11,000 mineral producers within its area, and the burden of compiling and keeping up the lists of producers is no small one. By the co-operative arrangement the State has the benefit of the accumulated experience of a number of years of the United States Survey, with the use of

the lists of the producers which that survey has compiled; and, while all the producers are not on these lists, it must be said that there are but few who are omitted. The benefit of the co-operative arrangement is apparent to all.

It is proper that we should have some statement of the mineral production of the State during the past few years which can be used for comparison with the detailed output collected during the past winter, and it is the object of this chapter to set forth briefly the results of the compilations made by the United States Survey in past years.

As stated in the last bi-ennial report, the State of Pennsylvania far exceeds in the value of its mineral production any other state, in fact, exceeds the production of all the States west of the Mississippi river. The total production is not far from $\frac{1}{3}$ of the total of the entire United States.

Not only in the total does Pennsylvania exceed all the other states, but notwithstanding its relatively large area, the product exceeds all other states in the average value per square mile of area.

The mineral production of the United States in the year 1905, for the first time, exceeded a total value of $1,500,000,000 and in 1907 the value exceeded $2,000,000,000. The effect of the financial depression of the latter part of 1907 so affected the output of 1908 that the mineral production fell to slightly less than $1,600,000,000, but in 1909, with the return of business throughout the country, it increased to $1,886,000,000 and in 1910 again exceeded the $2,000,000,000 mark. The following table gives the total mineral production of the United States and of Pennsylvania for several years, together with the percentage of the total production in our own State.

Table Number 1.

Value of Mineral Production of the United States and of Pennsylvania.

Year.	Total value, United States.	Pennsylvania.	
		Total value.	Percentage of U. S.
1907,	$2,071,617,964	$657,783,345	31.7
1908,	1,595,670,186	473,683,212	29.7
1909,	1,886,772,843	549,860,811	29.1
1910,	2,003,744,869	591,602,573	29.5

The Production of Pennsylvania.

The following table shows the value of the several mineral products of Pennsylvania for the years 1907-1910. It will be noted that this table includes the value of the Pig Iron produced in the State, which is mainly made from ores mined elsewhere, and in this respect does not accurately show the value of the raw material. But the proportionate value of the pig iron product of Pennsylvania, as compared with the value of its entire production, is less than that of the next larger states in value, and hence, if the pig iron value is used in comparing the states, one with another, the relative effect is against Pennsylvania, rather than in its favor.

TABLE NUMBER 2.

Value of Mineral Production of Pennsylvania.

	1907.		1908.		1909.		1910.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Cement, natural, barrels,	625,871	$263,969	252,479	$87,192	295,085	$98,673	196,331	$56,777
Cement, Portland, barrels,	20,393,965	19,698,006	18,254,806	13,899,807	22,869,614	15,969,621	26,675,978	19,551,268
Clay products,	----------	20,291,621	----------	14,842,982	----------	21,186,713	----------	22,094,285
Anthracite coal, long tons,	76,432,421	163,584,056	74,347,102	158,178,849	72,374,249	149,181,587	75,433,246	160,275,302
Bituminous coal, short tons,	150,143,177	155,664,026	117,179,527	118,816,303	137,966,791	130,085,237	150,521,526	153,029,510
Felspar, short tons,	19,633	136,847	14,089	103,502	18,573	111,466	15,091	104,751
Glass sand, short tons,	370,977	489,989	405,028	484,353	281,120	399,707	434,147	617,200
Graphite, pounds,	1,674,000	51,960	356,000	16,740	2,098,000	116,466	1,392,767	82,194
Iron ore, long tons,	873,287	1,298,717	443,161	572,346	666,889	792,672	739,799	911,847
Iron, pig, long tons,	11,348,549	234,952,000	6,987,191	111,385,000	10,918,824	175,429,000	11,272,323	180,695,338
Lime, short tons,	655,166	2,075,842	582,352	1,883,496	885,239	2,532,454	877,714	2,440,350
Paint and mortar colors, short tons,	10,327	127,973	9,197	113,112	16,174	196,067	10,774	125,466
Mineral waters, gallons,	1,287,063	235,807	1,430,489	180,889	2,177,967	240,856	2,536,337	221,685
Natural gas,	----------	18,844,156	----------	19,104,944	----------	20,475,207	----------	21,067,211
Ocher, short tons,	8,047	76,816	9,286	78,956	4,137	45,472	3,642	32,254
Petroleum, barrels,	9,999,306	17,579,706	9,424,325	16,881,194	9,299,403	15,424,554	8,794,662	11,908,914
Sand and gravel, short tons,	5,428,471	2,292,579	3,725,414	1,718,703	4,918,627	2,113,363	5,242,362	2,357,021
Sand lime, brick,	----------	48,410	----------	64,123	----------	62,255	----------	72,827
Slate,	----------	3,855,640	----------	3,902,958	----------	2,892,358	----------	3,740,806
Stone,	----------	9,132,372	----------	6,371,152	----------	8,125,723	----------	8,571,518
Clay,	382,620	618,143	243,157	466,385	379,387	644,411	396,238	636,613
Other products,	----------	6,876,111	----------	4,952,349	----------	5,174,032	----------	4,567,896

Leading Mineral Products in the State.

That the rank of Pennsylvania as a mineral producer should be understood, some of the more important products are tabulated in the following tables, which show the value of the entire output of the several minerals in the United States; the value of the output in Pennsylvania, and the percentage which the output of Pennsylvania bears to that of the entire United States.

Anthracite Coal.

The entire output of the anthracite coal is from the hard coal region of Pennsylvania. It is the intention, under the co-operative arrangement, to secure the data with greater detail than in the past. The following table and diagram illustrate the total tonnage of anthracite coal and the value of the same, together with the fluctuation for the years 1903-1911.

TABLE NUMBER 3.

Anthracite Coal.

Year.	Gross Tons.	Value.
1903,	66,613,454	$152,036,448
1904,	65,318,490	138,974,020
1905,	69,339,152	141,879,000
1906,	63,645,010	131,917,694
1907,	76,432,421	163,584,056
1908,	74,347,102	158,178,849
1909,	72,374,249	149,181,587
1910,	75,433,246	160,275,302
	863,503,124	$1,196,026,956

Bituminous Coal.

Second only to the production of anthracite coal is that bituminous coal. From the years 1903 to 1910 the output of bituminous coal in the State increased from 103,000,000 tons to 150,000,000 tons, over 45% and the *value* of the output rose from $121,000,000 to $153,000,000 an increase of about 26%. During the same time the total bituminous output (including lignite) of the entire United States rose from 282,000,000 tons to 417,000,000 tons, an increase of 48%; while the value rose from $351,000,000 to $468,000,000 and increase of 34%. The accompanying table and diagram will more fully illustrate the fluctuations during this time and, likewise the effect of the depression in business in the year 1907 upon the output of 1908-1909. The fact that the decrease in price in Pennsylvania is greater than the average, both in actual cents per ton and also in percentage of loss, is to be noticed. In the entire United States, the average price fell from $1.244 per ton in 1903, to $1.125 per ton in 1910, a loss of 11.9 cents

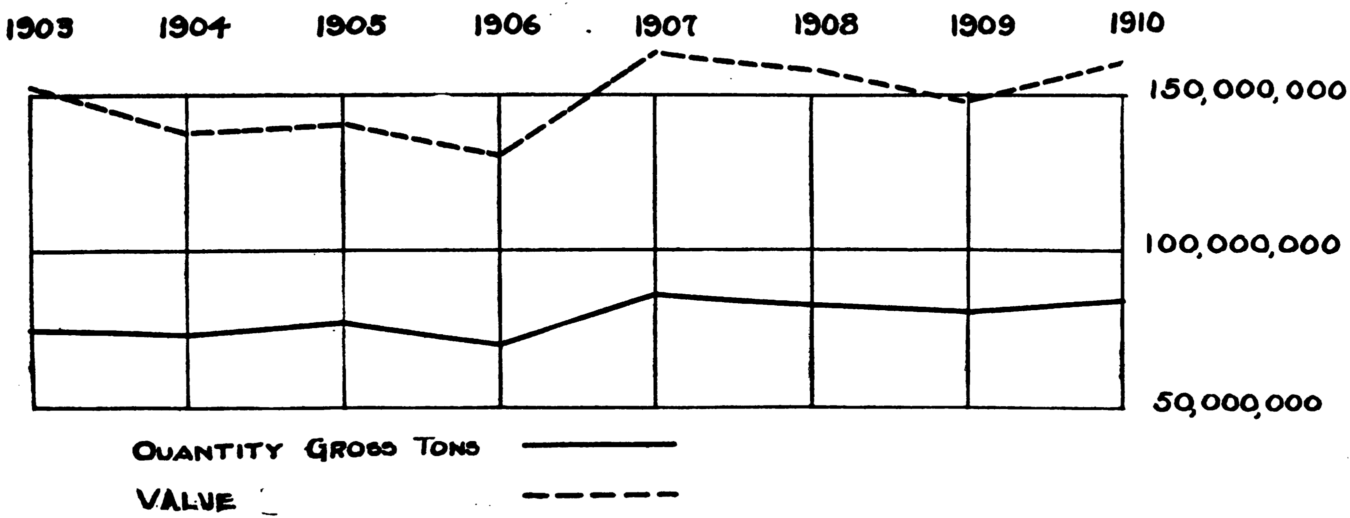


Figure 4. Diagram showing the production of anthracite coal.

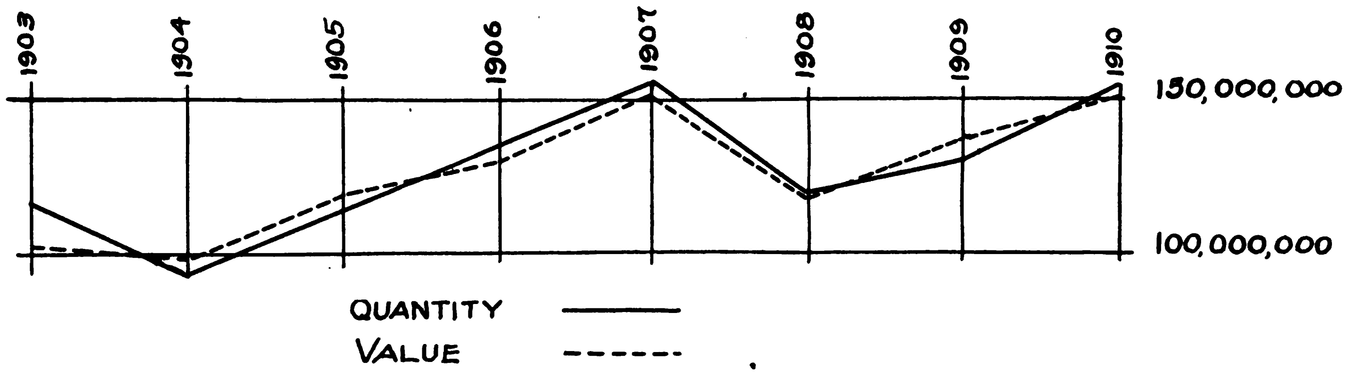


Figure 5. Diagram showing the production of bituminous coal.

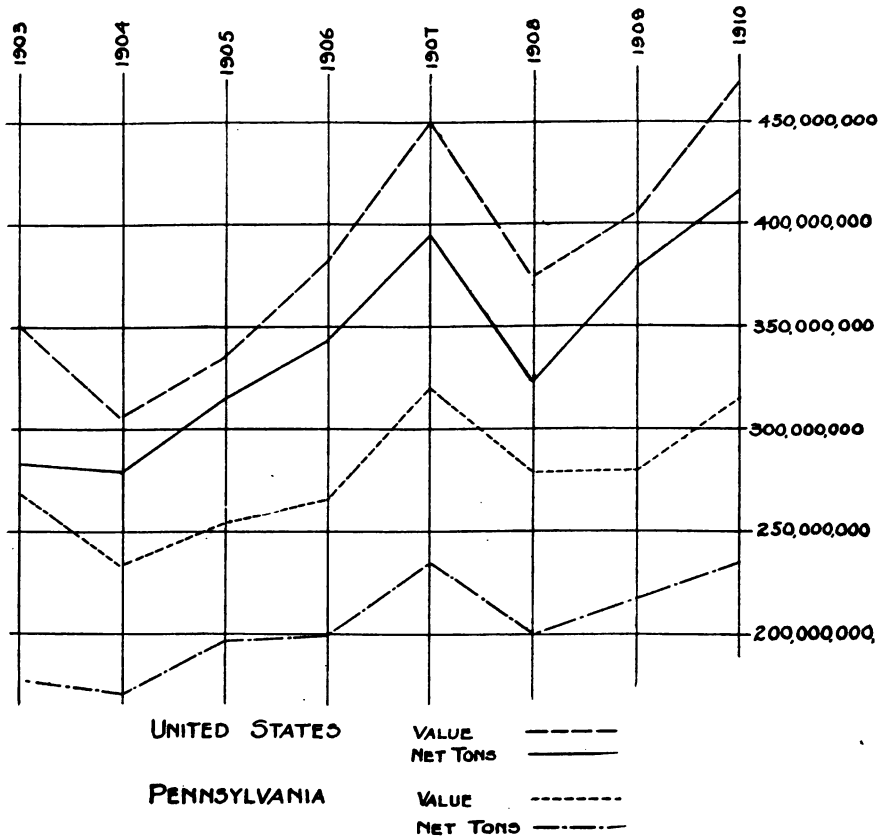


Figure 6. Diagram showing the total production of coal.

per ton, or 9.56%. In the same period in Pennsylvania the average price fell from $1.18 in 1903 to $1.016 a loss of 16.4 cents per ton, or 13.9%.

The vast inroads which are being made upon the bituminous coal of the State is perhaps better illustrated in the case of Fayette and Westmoreland counties than in any other section, although this is in part due to the fact we have more accurate data of the output of these fields than is at present available in other portions of the State.

The total output of bituminous coal in Pennsylvania for the years 1840 to 1910 was 2,251,737,097 net tons and of this amount 685,104,227 tons were mined during the last five years, or 30.43% of the total output. Of the amount mined during the last five years Fayette and Westmoreland counties produced about 262,000,000 tons or 38.25% of all that mined in the State. Practically all of the output for these two counties is from the Pittsburgh vein, the portion being mined from other horizons being almost nothing. This 262,000,000 tons represents about 10% of all the recoverable Pittsburgh coal originally in these two counties. In other words the total coal originally present in these two counties would last but 50 years at the average rate of mining during the last five years. Data is not at hand to give the total amount of coal mined in these two counties. During the 23 years from 1888 to 1910 there was shipped a total of 10,671,987 cars of coke from the Connellsville and Lower Connellsville regions which at an average of 25 tons to a car represents over 400,000,000 tons of coal coked. During the last five years the amount of coal coked in these two regions represents about ⅔ of the total coal output and, therefore, the total output of these two counties for the last 23 years would be over 600,000,000 tons. It therefore seems evident that fully ⅓ of the original amount of the Pittsburgh coal has been taken from these two counties and that the remaining portion cannot long withstand the tremendous drain now being made upon it.

TABLE NUMBER 4.

Bituminous Coal.

Year.	United States.		Pennsylvania.	
	Net Tons.	Value.	Net Tons.	Value.
1903,	282,749,248	$351,687,983	103,117,178	$121,752,759
1904,	278,659,689	305,397,001	97,938,287	94,428,219
1905,	315,062,785	334,658,294	118,413,637	113,390,507
1906,	342,874,867	381,162,115	129,293,206	130,290,651
1907,	394,759,112	451,214,842	150,143,177	155,664,026
1908,	332,576,944	374,135,268	117,179,527	118,816,303
1909,	379,744,237	405,486,777	137,966,791	130,085,237
1910,	417,111,142	469,281,719	150,521,526	153,029,510
	2,143,538,144	$3,073,024,949	1,004,573,329	$1,017,457,212

11

Coke.

The coke of the Connellsville region has long been recognized as the standard for the United States. From the year 1903 to the year 1910 the amount of bituminous coal made into coke in the United States rose from 39,000,000 tons to 63,000,000 tons, an increase of 61%, while in the same period the coal made into coke in Pennsylvania increased from 23,000,000 tons to 39,000,000 tons an increase of 69%. During the same period the total tonnage of the coke produced in the United States rose from 25,000,000 tons to 41,000,000, while the output from Pennsylvania increased from 15,000,000 tons to 26,000,000 tons. All this is shown in greater detail in the accompanying tables and diagrams which illustrates the fluctuation in the several years from 1903 to 1910.

TABLE NUMBER 5.

Coal Made into Coke—Net Tons.

Year.	United States.	Pennsylvania.
1903,	39,423,525	23,724,207
1904,	36,531,608	22,432,064
1905,	49,530,677	31,030,345
1906,	55,746,874	34,503,513
1907,	61,946,109	39,733,177
1908,	39,440,837	23,215,964
1909,	59,354,937	36,983,568
1910,	63,088,327	39,455,785
	405,062,394	251,078,623

TABLE NUMBER 6.

Quantity of Coke Produced in Net Tons.

Year.	United States.	Pennsylvania.
1903,	25,274,281	15,650,932
1904,	23,661,106	14,861,064
1905,	32,231,129	20,573,736
1906,	36,401,217	23,060,511
1907,	40,779,564	26,513,214
1908,	26,033,518	15,511,534
1909,	39,315,065	24,905,525
1910,	41,708,810	26,315,607
	267,392,223	165,405,690

The great increase in the production of coke in Pennsylvania is shown by the number of ovens, the quantity of coal coked, and the resulting coke. The following table shows these facts and also the percentage of coke produced from the coal used, which from years 1880 to 1910 shows a slight increase.

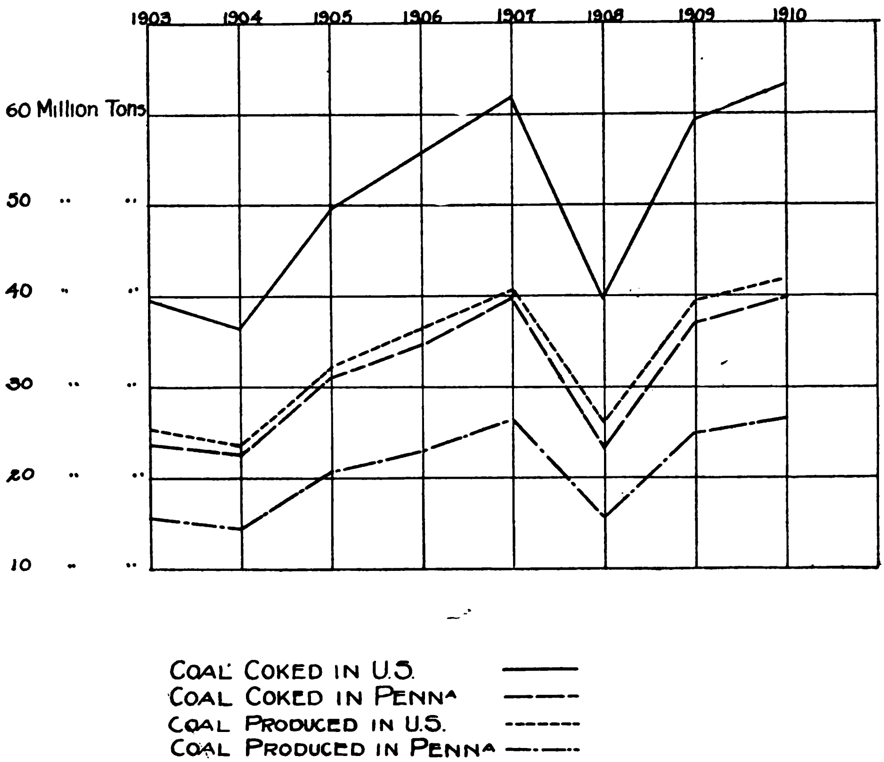


Figure 7. Diagram showing the amount of coal coked and coke produced in the United States and Pennsylvania.

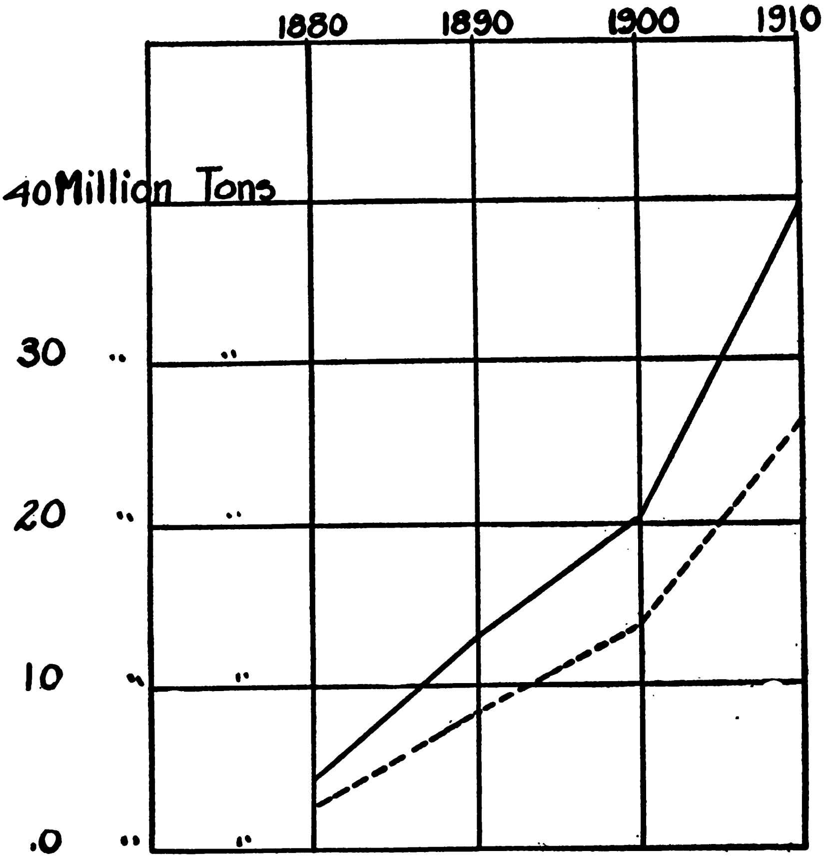


Figure 8. Diagram showing the amount of coal coked and coke produced in Pennsylvania, 1880-1910.

TABLE NUMBER 7.

Coke Produced in Pennsylvania.

Year.	Ovens.	Coal used, net tons.	Coke made, net tons.	Yield per cent..
1880,	9,501	4,347,558	2,821,284	65.0
1890,	23,430	13,046,143	8,560,245	65.6
1900,	32,548	20,239,969	13,357,295	66.0
1910,	55,656	39,455,785	26,315,607	66.7

The Connellsville Region.

The Connellsville region was long the ruling factor in the production of coke in Pennsylvania owing to the peculiar character and

value of coke making of the coal in that section. The following tables shows the number of ovens, the coal used, and the coke produced, at intervals of ten years in this region.

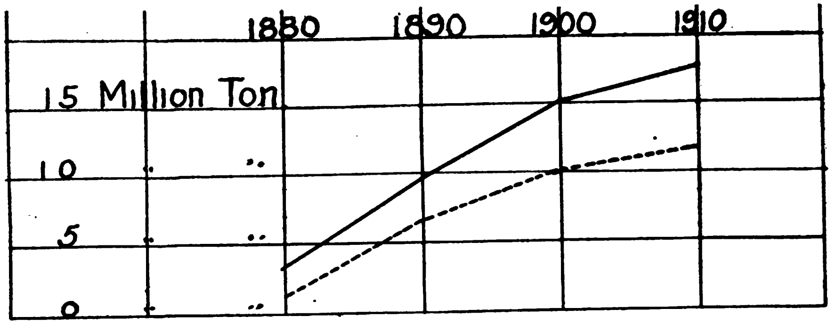


Figure 9. Diagram showing the amount of coal coked and coke produced in the Connellsville region.

TABLE NUMBER 8.

Connellsville Region.

Year.	Ovens.	Coal used, net tons.	Coke made, net tons.	Yield per cent..
1880,	7,211	3,367,856	2,205,946	65.5
1890,	15,865	9,748,449	6,464,156	66.3
1900,	20,981	14,946,659	10,026,907	67.0
1910,	24,481	17,205,615	11,459,601	66.6

Lower Connellsville Region.

In the year 1900 it was found that the coal lying outside of the Connellsville region proper could be made into high grade coke, and accordingly a part of the coke industry was transferred to the region southwest of Connellsville, toward the Monongahela River and the West Virginia state line. The accompanying table shows the number of ovens, the quantity of coal used and the resulting coke of the "Lower Connellsville" region for the years 1900, 1905, and 1910.

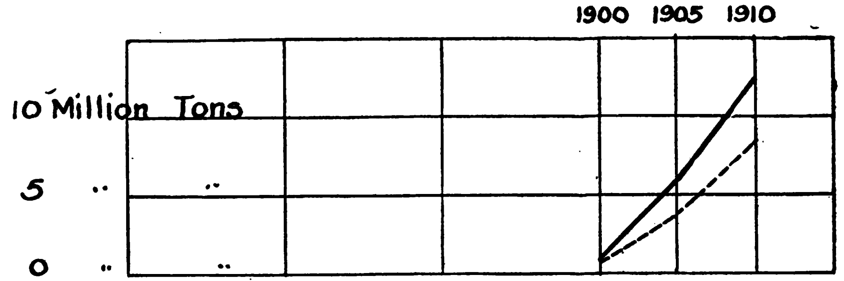


Figure 10. Diagram showing the amount of coal coked and coke produced in the Lower Connellsville region.

TABLE NUMBER 9.

Lower Connellsville Region (Opened in 1900).

Year.	Ovens.	Coal used, net tons.	Coke made, net tons.	Yield per cent..
1900,	2,033	579,928	385,909	66.5
1905,	7,484	5,666,812	3,871,810	68.3
1910,	14,805	12,130,425	8,219,492	67.8

Cement.

Pennsylvania has long been a prominent factor in the production of cement, both Natural and Portland, and the production of both classes of cement in the United States and Pennsylvania is shown on the accompanying table and diagram.

During the period covered by the table it will be seen the output of Natural Cement has declined rapidly, as the output of Portland Cement has increased. This is true not only of the output in Pennsylvania but, likewise, in a more marked degree in the output of the entire United States.

Pennsylvania has long held first rank as the producer of Portland Cement and the quantity produced has had an almost continuous increase from year to year, during the time covered by the accompying table. For the year 1903 the value of the Portland Cement was slightly in excess of $1.00 per barrel, not only in the United States as a whole, but in Pennsylvania as well. During the year 1904 the price fell below $1.00 per barrel both in the United States and Pennsylvania. During the following year, 1905, the general price in the United States again rose above the dollar mark and continued until 1907 but since that time the price has uniformly been less than $1.00

per barrel. In Pennsylvania, however, since the year 1903 the average price has been constantly below the $1.00 mark and it would not seem as if in the future it will rise beyond that price.

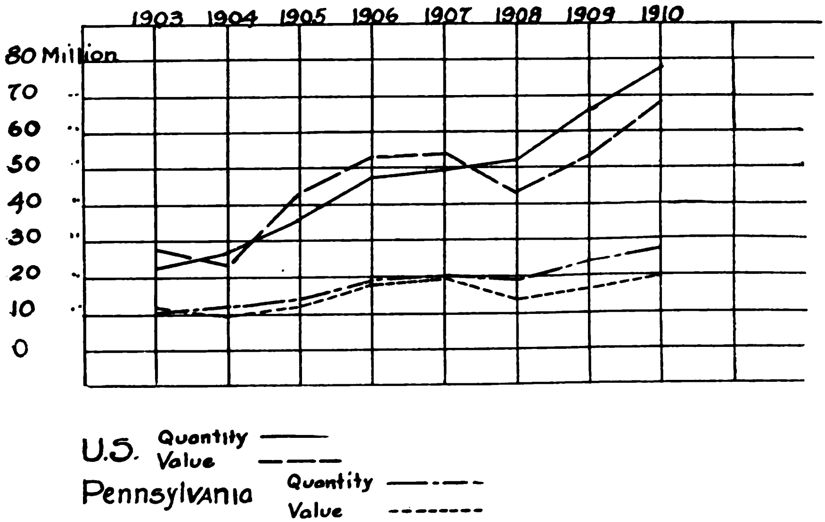


Figure 11. Diagram showing the value and production of Portland cement.

More detailed information of Portland Cement Industry in the State will be found in the preliminary report on that subject, recently issued by this survey.

TABLE NUMBER 10.

Cement Produced in the United States.

Year.	Natural.		Portland.	
	Barrels.	Value.	Barrels.	Value.
1903,	7,030,271	$3,675,520	22,342,973	$27,713,319
1904,	4,866,331	2,450,150	26,505,881	23,355,119
1905,	4,473,049	2,413,052	35,246,812	33,245,867
1906,	4,055,797	2,423,170	46,463,424	52,466,186
1907,	2,887,700	1,467,302	48,785,390	53,992,551
1908,	1,686,682	834,509	51,072,612	43,547,679
1909,	1,537,638	652,756	64,991,431	52,858,354
1910,	1,139,239	483,006	76,549,951	68,205,800
	27,676,707	$14,399,465	371,958,474	$355,389,875

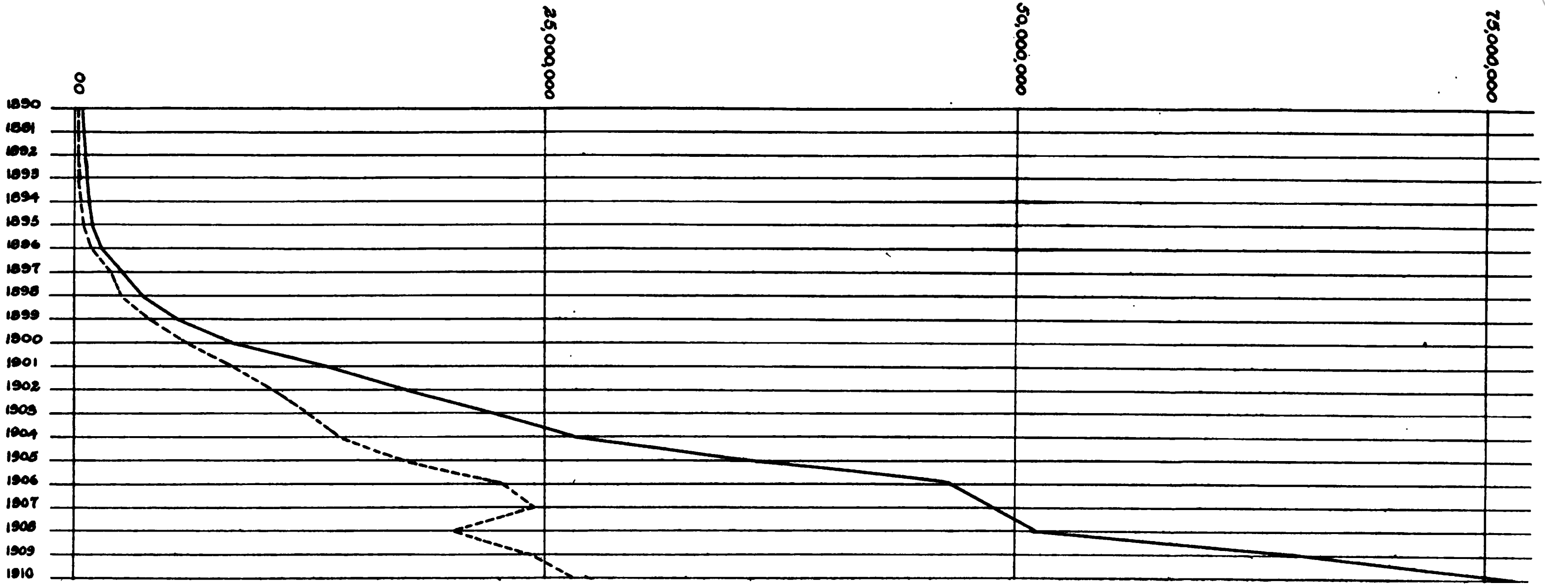


Figure 13. Diagram showing total production of Portland cement in the United States and the Lehigh district.

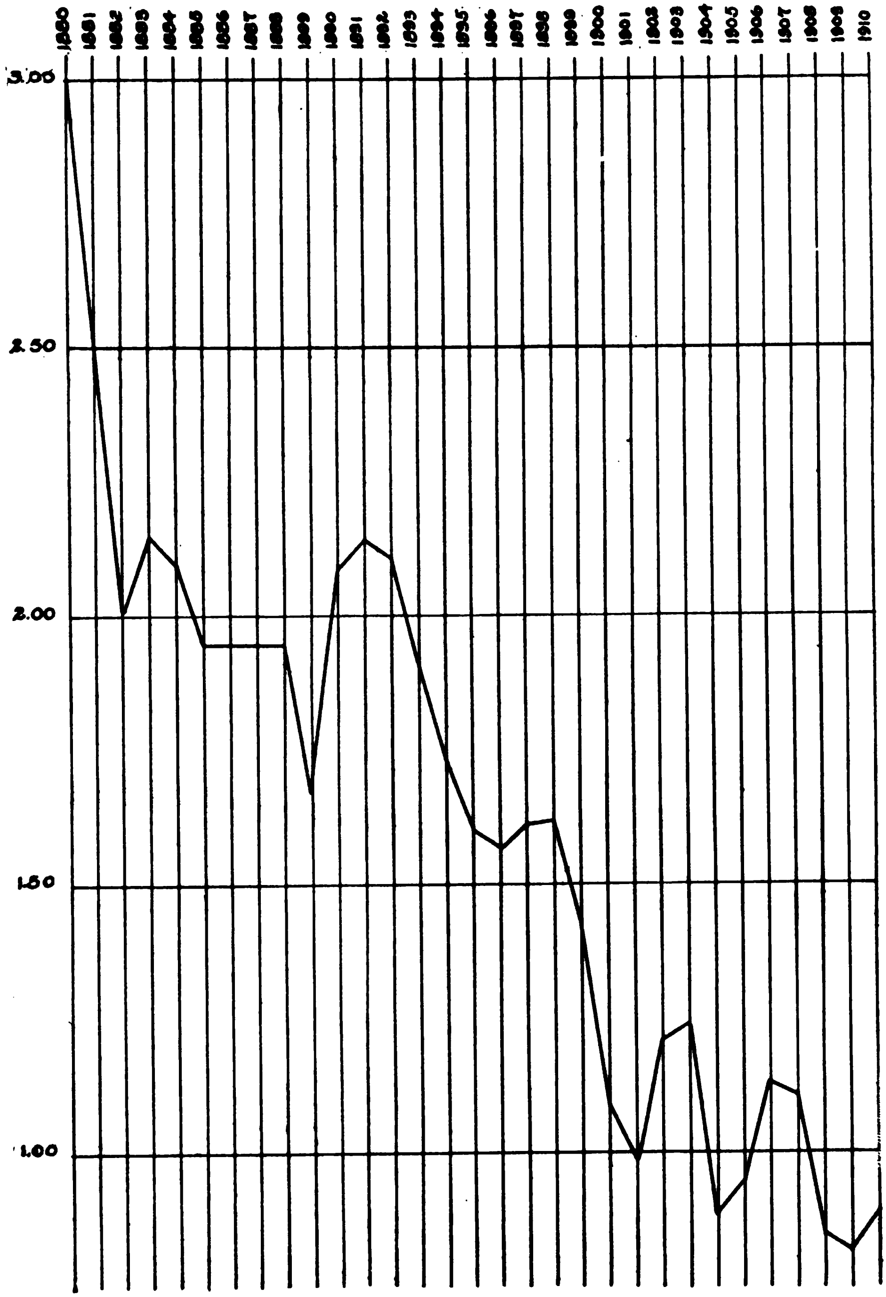


Figure 14. Diagram showing decrease in price of Portland cement.

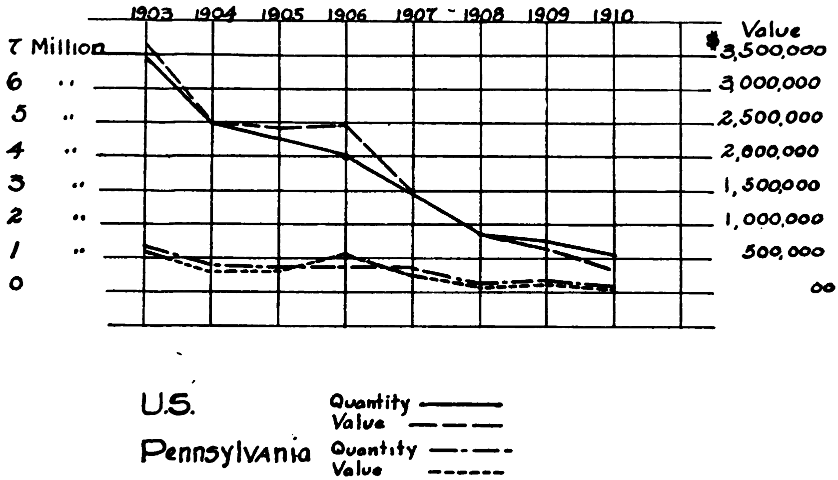


Figure 12. Diagram showing the value and production of natural cement.

TABLE NUMBER 11.

Cement Produced in Pennsylvania.

Year.	Natural.		Portland.	
	Barrels.	Value.	Barrels.	Value.
1903,	1,339,090	$576,269	9,754,313	$11,205,892
1904,	770,897	298,533	11,496,099	8,969,206
1905,	748,057	306,555	13,813,487	11,195,940
1906,	744,403	560,534	18,645,015	18,598,439
1907,	625,871	263,969	20,393,965	19,698,006
1908,	252,479	87,192	18,254,806	13,899,807
1909,	295,085	98,673	22,869,614	15,969,621
1910,	196,331	56,777	26,675,978	19,551,263
	4,972,213	$2,248,502	141,903,277	$119,088,179

Clay Products.

Pennsylvania holds high rank as a producer of Clay products, being only second to the state of Ohio. The following table and diagram shows the value of the clay products in the United States and Pennsylvania for the years 1903 to 1910.

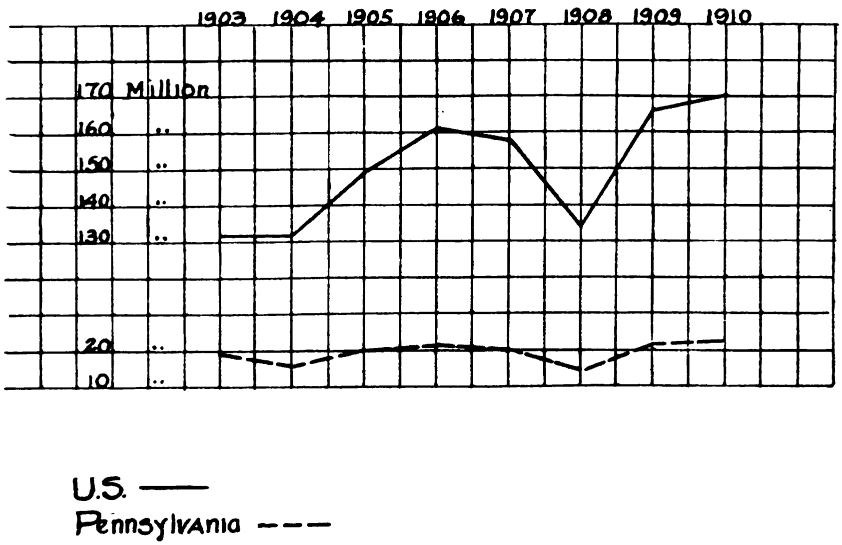


Figure 15. Diagram showing value of clay products.

TABLE NUMBER 12.

Clay Products.

Year.	United States. Value.	Pennsylvania. Value.
1903,	$131,062,421	$18,847,324
1904,	131,023,248	16,821,863
1905,	149,697,188	19,124,553
1906,	161,132,722	21,774,611
1907,	158,942,369	20,291,621
1908,	133,197,762	14,842,982
1909,	166,321,213	21,186,713
1910,	170,115,974	22,094,285
	$1,201,492,897	$154,983,952

Refractories.

In the production of refractory materials Pennsylvania leads all the other states, producing over 46% of the entire output, as is shown by the accompanying tables and diagram. The effect of the depression in business in the year 1908 is especially marked in the production of fire brick as is shown by the table, and the fact the fire brick industry is so largely dependent on the iron industry in the State is well illustrated in the values of refractories for the years 1908 and 1909. For the year 1909 the value of the entire output of fire brick in the United States increased $6,000,000 over the output in 1908. Of this increase two-thirds, or, $4,000,000, is represented by the increase in Pennsylvania, while the value of the output of Pennsylvania was less than 50% of that of the United States, showing the quick response to the improvement in the iron and steel business by the fire brick industry in this State.

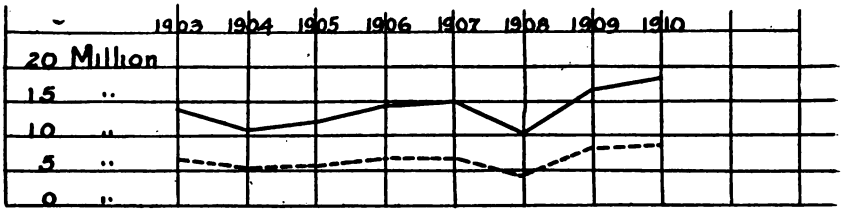


Figure 16. Diagram showing the value of fire brick production.

TABLE NUMBER 13.

Production of Fire Brick.

Year.	United States. Value.	Pennsylvania. Value.
1903,	$14,062,369	$6,537,076
1904,	11,167,972	5,477,475
1905,	12,735,404	5,771,795
1906,	14,206,868	6,854,640
1907,	14,946,045	6,907,904
1908,	10,696,216	4,252,325
1909,	16,620,695	8,107,807
1910,	18,111,474	6,454,928
	$112,547,043	$50,363,950

Iron Ore.

While Pennsylvania produces but little iron ore, relatively, yet the value of the output of Pennsylvania is greater than is generally supposed. The accompanying tables shows the output of iron ore of the

United States, the Lake Superior region and of Pennsylvania in the years of 1904 to 1910.

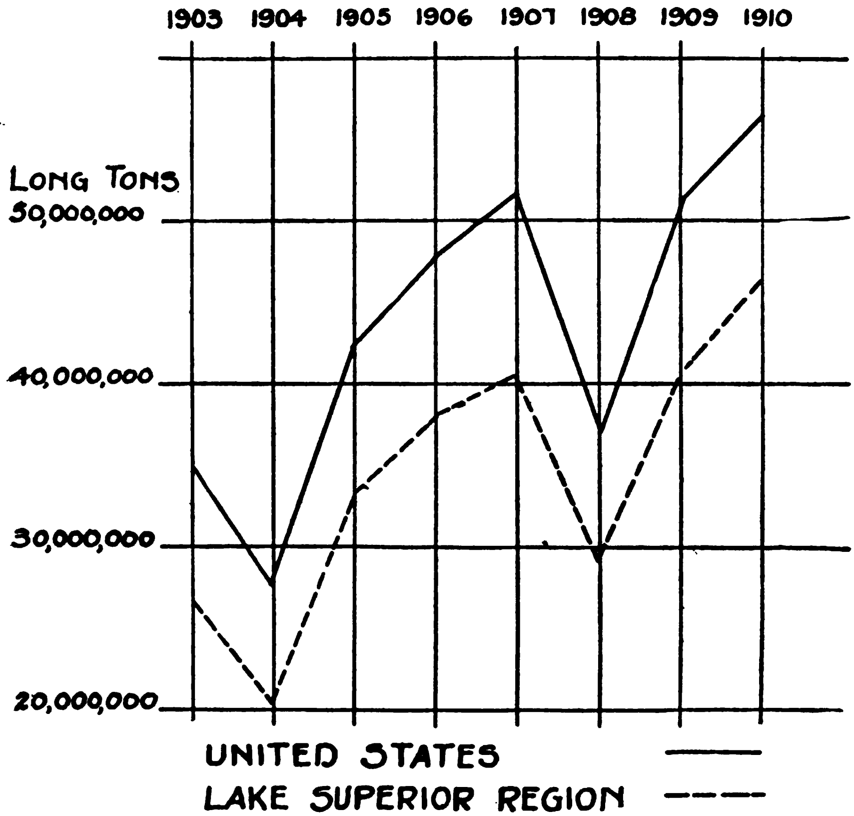


Figure 17. Diagram showing the production of iron ore in the United States and in the Lake Superior region.

TABLE NUMBER 14.

Iron Ore Produced in the United States and in the Lake Superior Region.

Year.	United States. (Gross Tons.)	Superior Region. (Gross Tons.)
1904,	27,644,330	20,198,811
1905,	42,526,133	33,325,018
1906,	47,749,728	38,085,084
1907,	51,720,619	41,638,744
1908,	35,924,771	28,225,412
1909,	51,155,437	41,942,969
1910,	56,889,734	46,420,226
	313,610,752	249,735,964

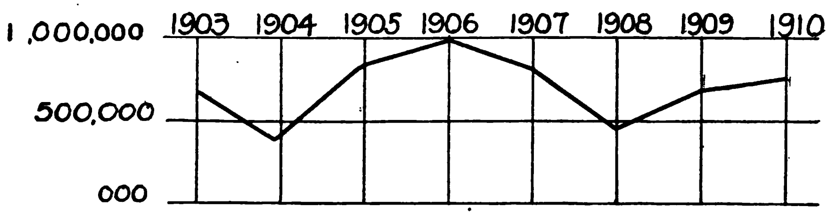


Figure 18. Diagram showing production of iron ore in Pennsylvania.

TABLE NUMBER 15.

Iron Ore Produced in Pennsylvania.

Year.	Quantity. Gross Tons.	Value.
1904,	397,107	$611,211
1905,	808,610	1,060,162
1906,	949,429	1,246,267
1907,	837,287	1,298,717
1908,	443,161	572,846
1909,	666,889	792,672
1910,	739,799	911,847
	4,842,282	$6,493,222

Petroleum.

When one considers how long a time a continuous drain has been exhausting the petroleum resources of the State, it is astonishing how well the output is maintained. The following table gives the value of the petroleum output for the years 1901 to 1910, from which it will be noted that in this period there has been a decline of about 30%.

There are today in Pennsylvania, upwards of 50,000 oil wells and, while many have been abandoned from year to year, the total number seems to be on the increase. During the years 1909 and 1910 there were drilled in Pennsylvania and New York 5,233 producing oil wells, while during the same period the reports show 1,935 wells abandoned. In the same period 1,191 dry holes were drilled.

The petroleum industry has added great wealth to the State of Pennsylvania and while it would seem that the supply is being rapidly exhausted, yet in view of this fact and of the unequaled quality of the Pennsylvania oil, this is a most profitable field for Geological study and one which deserves a most liberal treatment by the State. Much has been written in the reports of the Second Geological Survey on the oil region, but during the time which has elapsed since the close of the field work by that organization, many discoveries have been made, thousands of new wells have been drilled, new fields have been

opened and developed, an above all the relations of the Geological Structure to the accumulation of oil and gas in paying quantities has been worked out and tested by actual drilling. With the accurate maps that are now, or soon will be, available, it is possible in many places to direct the driller in the development and opening of new pools which may exist, and to guard against the useless drilling of wells in places where the structure is such as to not admit of the accumulation of oil and gas in paying quantities. The work of the geologist in directing the driller is one of the most practical and profitable fields of the Geological engineer.

During the time covered by the table, the Pennsylvania production fell from 12,625,378 barrels in 1901 to 8,794,662 in 1910, 3,830,716 barrels, or 31.13%. In the same period in New York, the production fell from 1,206,618 barrels in 1901 to 1,053,838 barrels in 1910,—152,-780 barrels, or 12.66%.

TABLE NUMBER 16.

Production of Petroleum in Pennsylvania.

Year.	Barrels.
1901,	12,625,378
1902,	12,063,880
1903,	11,355,156
1904,	11,125,762
1905,	10,437,195
1906,	10,256,893
1907,	9,999,306
1908,	9,424,325
1909,	9,299,403
1910,	8,794,662
	105,381,960

Natural Gas.

Of all the mineral products of the State, that of Natural Gas has shown the greatest fluctuation. Prior to 1883 but little gas was used in the State. The accompanying table shown the value of natural gas production of the State for the years 1883 to 1910. Starting with the value of $200,000 in 1883, the value of the gas rose to over $19,000,-000 in five years, and gradually declined the next eight years to $5,-500,000. Since 1896, however, there has been a gradual increase in the value of the gas produced, until, in 1910 it has reached the value of over $21,000,000, exceeding by $2,000,000, the value of the year 1888. This increase in value was only accomplished by a greatly increased investment on the part of the producers of the State. In 1897 the reported number of gass wells was 2,467 and in 1910 this had increased

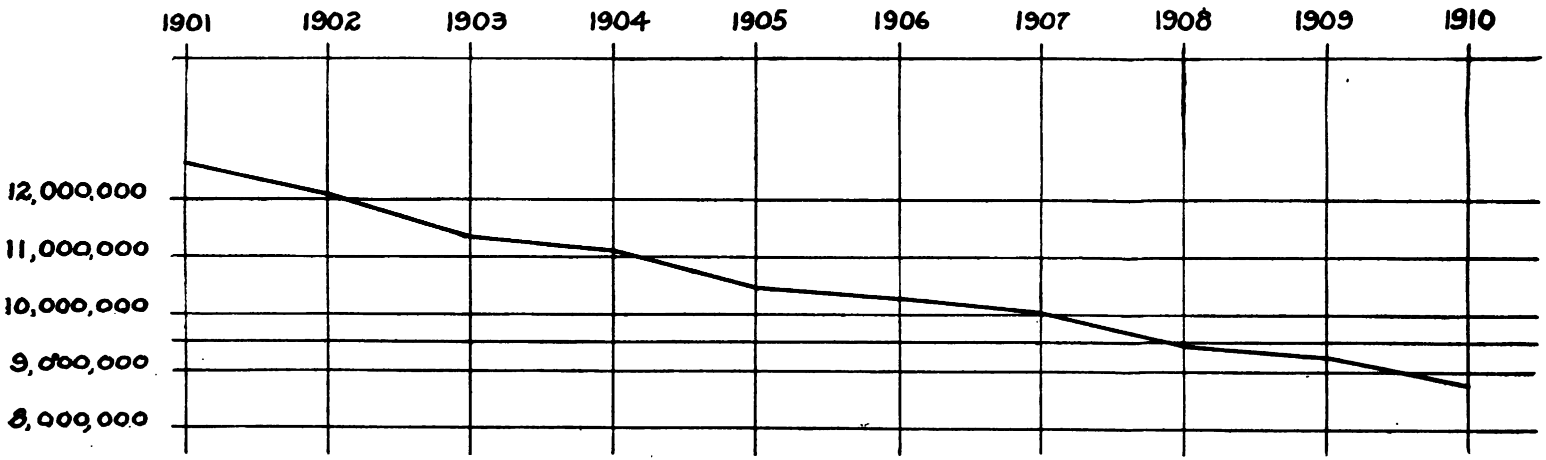


Figure 19. Diagram showing the production of petroleum in Pennsylvania, 1901-1910.

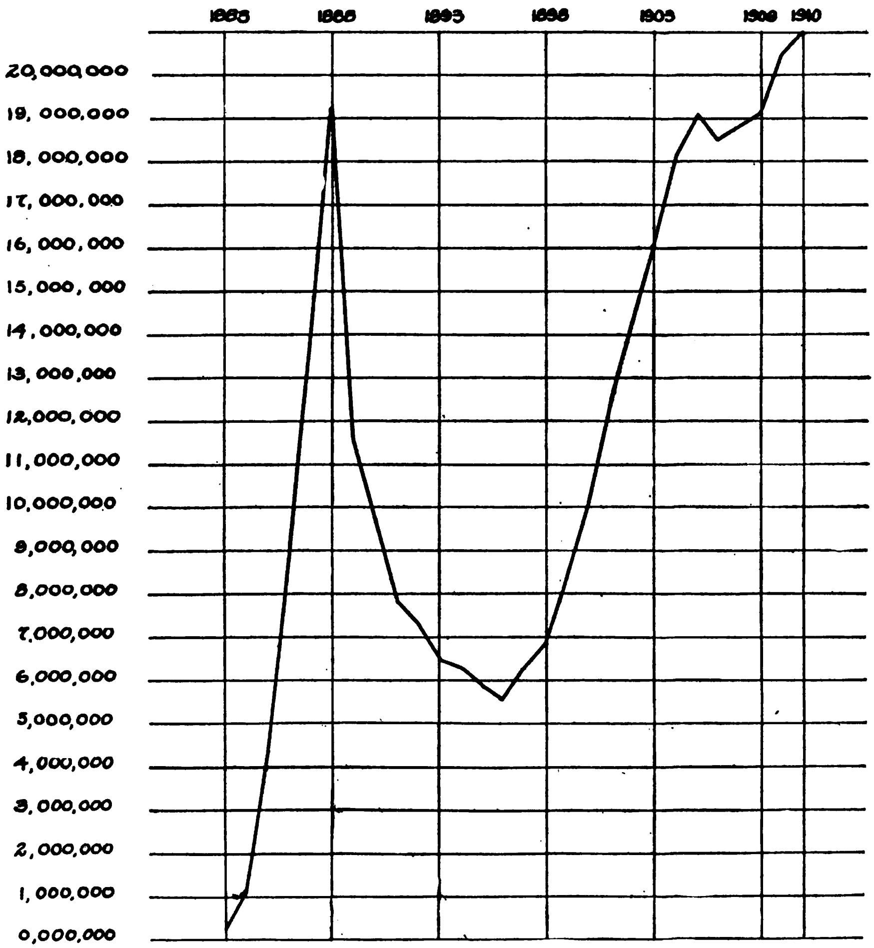


Figure 20. Diagram showing the value of natural gas produced in Pennsyl vania, 1883-1910.

to 9,800, and in order to maintain the supply, the number of wells drilled for gas in the years 1909 and 1910 was 1,940, of which 327 were dry holes. This number of wells does not include the low pressure wells of Erie county, of which 429 reported in the year 1910.

TABLE NUMBER 17.

Natural Gas in Pennsylvania.

Year.	Value.
1883,	$200,000
1884,	1,100,000
1885,	4,500,000
1886,	9,000,000
1887,	13,749,500
1888,	19,282,375
1889,	11,593,980
1890,	9,551,025
1891,	7,834,016
1892,	7,376,281
1893,	6,488,000
1894,	6,279,000
1895,	5,852,000
1896,	5,528,610
1897,	6,242,543
1898,	6,806,742
1899,	8,337,210
1900,	10,215,412
1901,	12,688,161
1902,	14,352,183
1903,	16,182,834
1904,	18,139,914
1905,	19,197,336
1906,	18,558,245
1907,	18,844,156
1908,	19,104,944
1909,	20,475,207
1910,	21,057,211
	$318,536,894

Stone.

The following table and diagram show the value of the stone output of the United States and Pennsylvania for the years 1904 to 1910, together with the percentage of the total produced by Pennsylvania, from which it will be noted that this State produced $\frac{1}{8}$ of the entire output of the United States and produced the largest quantity in value of any state, ranking first in production except for the year 1908, when it ranked second. This slight decline in the year 1908 was due to the reduced output of limestone occasioned by the effect of the business depression upon the iron and steel industry.

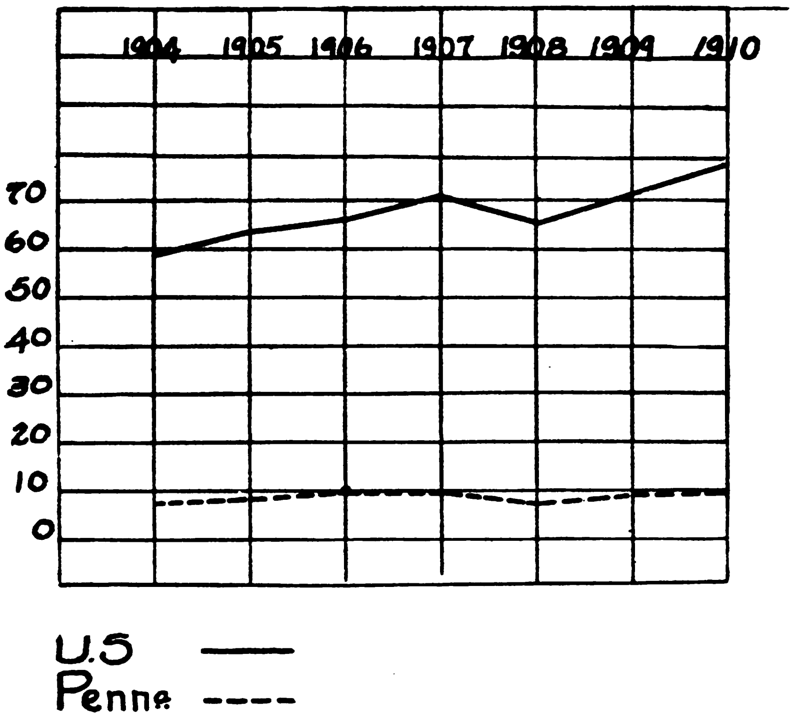


Figure 21. Diagram showing the value of stone production, 1904-1910.

TABLE NUMBER 18.

Production of Stone.

Year.	United States.	Pennsylvania.		
		Value.	Percentage of total.	Rank.
1904,	$58,765,715	$7,341,180	12.49	First.
1905,	63,798,748	7,956,177	12.47	First.
1906,	66,378,794	8,804,776	13.27	First.
1907,	71,105,805	9,132,372	12.84	First.
1908,	65,712,499	6,371,152	9.70	Second.
1909,	71,345,100	8,125,723	11.39	First.
1910,	76,520,584	8,571,518	11.20	First.
	$473,627,344	$56,302,898	11.88	

Sand and Gravel.

in the years 1905 to 1910 the total production of sand and gravel in the United States was 264,000,000 tons, with a value of $91,000,000. Of this amount Pennsylvania produced 30,000,000 tons of a total value

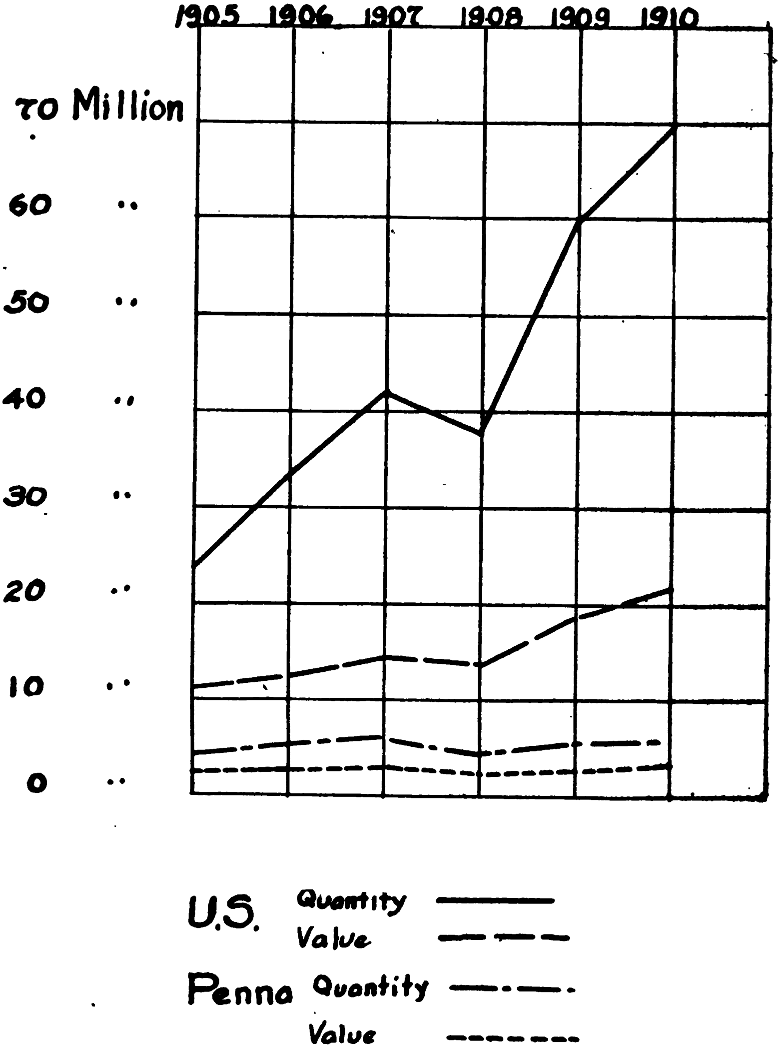


Figure 22. Diagram showing production of sand and gravel, 1905-1910.

of $15,000,000. The range of production and value is shown on the accompanying table and diagram, from which it will be seen the value per ton of the Pennsylvania output exceeds the average of the United States, by about 60%.

TABLE NUMBER 19.

Production of Sand and Gravel.

Year.	United States.		Pennsylvania.	
	Tons.	Value.	Tons.	Value.
1905,	23,174,967	$11,199,645	4,028,804	$2,236,309
1906,	32,932,002	12,698,208	5,232,875	2,480,811
1907,	41,851,918	14,492,069	5,799,448	2,782,568
1908,	37,216,044	13,270,032	4,130,442	2,208,056
1909,	59,565,551	18,336,990	5,199,747	2,513,070
1910,	69,410,436	21,037,630	5,676,509	2,974,221
	264,150,918	$91,034,574	30,067,825	$15,190,085

Slate.

Pennsylvania far exceeds any other state in the value of slate produced. It is the only state which produces slate suitable for some

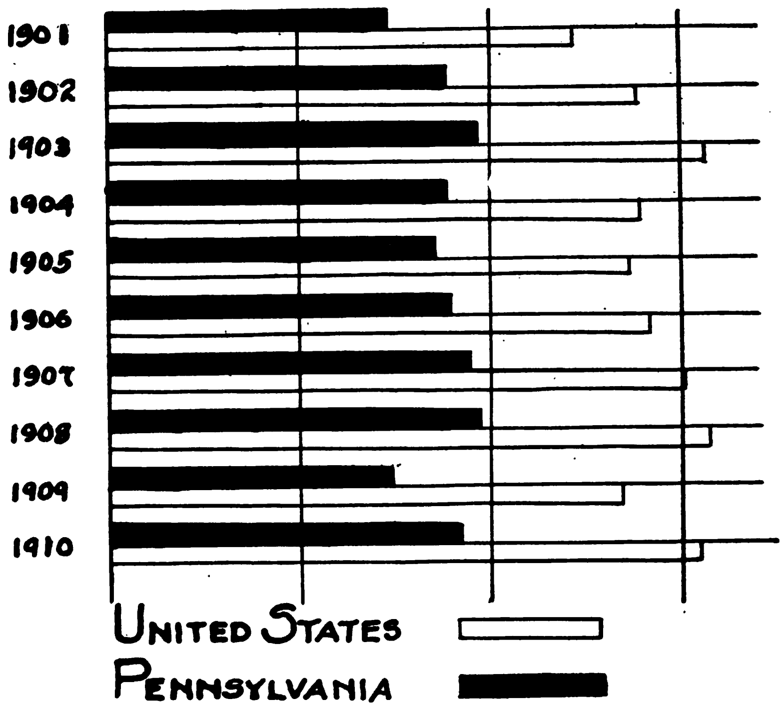


Figure 23. Diagram showing the production of slate, 1901-1910.

purposes. The following table and diagram illustrate the value of the slate production of United States in the years 1901 to 1910, and likewise the value of the production of Pennsylvania for the same years,

together with the percentage the production of the State bears to the total. It will be noted that the proportion of Pennsylvania varied from 53.15% in 1909 to 64.73% in 1904. The falling off in total in the year 1909 was due, as the table shows, to the great decline in output, owing to the local conditions, in Pennsylvania.

TABLE NUMBER 20.

Production of Slate.

Year.	United States.	Pennsylvania.	
	Value.	Value.	Percentage of Total.
1901.	$4,787,525	$2,984,264	62.34
1902.	5,696,051	3,547,322	62.28
1903.	6,256,885	3,959,906	63.28
1904.	5,617,195	3,633,246	64.66
1905.	5,496,207	3,491,905	63.53
1906.	5,668,346	3,522,149	62.14
1907.	6,019,220	3,855,640	64.05
1908.	6,316,817	3,902,958	61.79
1909.	5,441,418	2,892,358	53.15
1910.	6,236,759	3,740,806	59.98
	$57,536,423	$35,530,554	61.75

Lime.

The following table gives the value of the lime output in the United States for the years 1904 to 1910 together with the output in Pennsylvania and the percentage the output of this State bears to the entire production of the United States, from which it will be seen that Pennsylvania produced about one-seventh of the entire lime output of the country.

TABLE NUMBER 21.

Production of Lime.

Year.	United States.	Pennsylvania.	
	Value.	Value.	Percentage of Total.
1904.	$9,951,456	$1,537,673	15.4
1905.	10,941,680	1,672,267	15.3
1906.	12,480,653	1,857,754	14.1
1907.	12,640,512	2,075,842	16.4
1908.	11,091,186	1,883,496	16.9
1909.	13,846,072	2,532,454	18.3
1910.	13,894,962	2,440,350	17.6
	$84,846,521	$13,999,836	16.5

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